THE RICE INSTITUTE PAMPHLET

VOLUME ONE

Published by

THE RICE INSTITUTE

A university of liberal and technical learning founded by William Marsh Rice in the City of Houston, Texas, and dedicated by him to the advancement of Letters, Science, and Art

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Vol. I April, 1915 No. 1

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THE SEVERAL PIECES APPEARING IN THIS PAMPHLET ARE REPRINTED FROM A COMMEMORATIVE VOLUME INSCRIBED BY SPECIAL PERMISSION TO THE HONORABLE WOODROW WILSON, PH.D., LITT.D., LL.D., MAN OF LETTERS, LEADER OF MEN, THIRTEENTH PRESIDENT OF PRINCETON UNIVERSITY, TWENTY-EIGHTH PRESIDENT OF THE UNITED STATES, AND WHICH CONTAINS AN ACCOUNT OF AN ACADEMIC FESTIVAL HELD IN CELEBRATION OF THE FORMAL OPENING OF THE RICE INSTITUTE

THE RICE INSTITUTE PAMPHLETS

VOL. I — APRIL, 1915 — No. 1

CONTENTS

TEXAS

A DEMOCRATIC ODE

—

I

THE WILD BEES

ALL along the Brazos river,
All along the Colorado,
In the valleys and the lowlands
Where the trees were tall and stately,
In the rich and rolling meadows
Where the grass was full of wild-flowers,
Came a humming and a buzzing,
Came the murmur of a going
To and fro among the tree-tops,
Far and wide across the meadows.
And the red-men in their tepees
Smoked their pipes of clay and listened.
"What is this?" they asked in wonder;
"Who can give the sound a meaning?
Who can understand the language
Of a going in the tree-tops?"
Then the wisest of the Tejas
Laid his pipe aside and answered:
"O my brothers, these are people,
Very little, winged people,
Countless, busy, banded people,
Coming humming through the timber.
These are tribes of bees, united
By a single aim and purpose,
To possess the Tejas' country,

Gather harvest from the prairies,
Store their wealth among the timber.
These are hive and honey makers,
Sent by Manito to warn us
That the white men now are coming,
With their women and their children.
Not the fiery filibusters
Passing wildly in a moment,
Like a flame across the prairies,
Like a whirlwind through the forest,
Leaving empty lands behind them!
Not the Mexicans and Spaniards,
Indolent and proud hidalgos,
Dwelling in their haciendas,
Dreaming, talking of to-morrow,
While their cattle graze around them,
And their fickle revolutions
Change the rulers, not the people!
Other folk are these who follow
When the wild-bees come to warn us;
These are hive and honey makers,
These are busy, banded people,
Roaming far to swarm and settle,
Working every day for harvest,
Fighting hard for peace and order,
Worshiping as queens their women,
Making homes and building cities
Full of riches and of trouble.
All our hunting-grounds must vanish,
All our lodges fall before them,
All our customs and traditions,
All our happy life of freedom,
Fade away like smoke before them.

Come, my brothers, strike your tepees,
Call your women, load your ponies!
Let us take the trail to westward,
Where the plains are wide and open,
Where the bison-herds are gathered
Waiting for our feathered arrows.
We will live as lived our fathers,
Gleaners of the gifts of nature,
Hunters of the unkept cattle,
Men whose women run to serve them.
If the toiling bees pursue us,
If the white men seek to tame us,
We will fight them off and flee them,
Break their hives and take their honey,
Moving westward, ever westward,
There to live as lived our fathers."
So the red-men drove their ponies,
With the tent-poles trailing after,
Out along the path to sunset,
While along the river valleys
Swarmed the wild-bees, the forerunners;
And the white men, close behind them,
Men of mark from old Missouri,
Men of daring from Kentucky,
Tennessee, Louisiana,
Men of many States and races,
Bringing wives and children with them,
Followed up the wooded valleys,
Spread across the rolling prairies,
Raising homes and reaping harvests.
Rude the toil that tried their patience,
Fierce the fights that proved their courage,
Rough the stone and tough the timber

Out of which they built their order!
Yet they never failed nor faltered,
And the instinct of their swarming
Made them one and kept them working,
Till their toil was crowned with triumph,
And the country of the Tejas
Was the fertile land of Texas.

II

THE LONE STAR

Behold a star appearing in the South—
A star that shines apart from other stars,
    Ruddy and fierce, like Mars!
Out of the reeking smoke of cannon's mouth
That veils the slaughter of the Alamo,
    Where heroes face the foe,
One man against a score, with blood-choked breath
Shouting the watchword, "Victory or Death—"
Out of the dreadful cloud that settles low
    On Goliad's plain,
Where thrice a hundred prisoners lie slain
Beneath the broken word of Mexico—
Out of the fog of factions and of feuds
    That ever drifts and broods
Above the bloody path of border war,
    Leaps the Lone Star!

What light is this that does not dread the dark?
What star is this that fights a stormy way
    To San Jacinto's field of victory?
    It is the fiery spark

That burns within the breast
Of Anglo-Saxon men, who can not rest
Under a tyrant's sway;
The upward-leading ray
That guides the brave who give their lives away
Rather than not be free!
O question not, but honour every name,
Travis and Crockett, Bowie, Bonham, Ward,
Fannin and King, all who drew the sword
And dared to die for Texan liberty!
Yea, write them all upon the roll of fame,
But no less love and equal honour give
To those who paid the longer sacrifice—
Austin and Houston, Burnet, Rusk, Lamar
And all the stalwart men who dared to live
Long years of service to the lonely star.

Great is the worth of such heroic souls:
Amid the strenuous turmoil of their deeds,
They clearly speak of something that controls
The higher breeds of men by higher needs
Than bees, content with honey in their hives!
Ah, not enough the narrow lives
On profitable toil intent!
And not enough the guerdons of success
Garnered in homes of affluent selfishness!
A noble discontent
Cries for a wider scope
To use the wider wings of human hope;
A vision of the common good
Opens the prison-door of solitude;
And, once beyond the wall,
Breathing the ampler air,

The heart becomes aware
That life without a country is not life at all.
A country worthy of a freeman's love;
A country worthy of a good man's prayer;
A country strong, and just, and brave, and fair,—
A woman's form of beauty throned above
The shrine where noble aspirations meet—
To live for her is great, to die is sweet!

Heirs of the rugged pioneers
Who dreamed this dream and made it true,
Remember that they dreamed for you.
They did not fear their fate
In those tempestuous years,
But put their trust in God, and with keen eyes,
Trained in the open air for looking far,
They saw the many-million-acred land
Won from the desert by their hand,
Swiftly among the nations rise,—
Texas a sovereign State,
And on her brow a star!

III

THE CONSTELLATION

How strange that the nature of light is a thing beyond our ken,
And the flame of the tiniest candle flows from a fountain sealed!
How strange that the meaning of life, in the little lives of men,
So often baffles our search with a mystery unrevealed!

But the larger life of man, as it moves in its secular sweep,
Is the working out of a Sovereign Will whose ways appear;
And the course of the journeying stars on the dark blue boundless deep,
Is the place where our science rests in the reign of law most clear.

I would read the story of Texas as if it were written on high;
I would look from afar to follow her path through the calms and storms;
With a faith in the world-wide sway of the Reason that rules in the sky,
And gathers and guides the starry host in clusters and swarms.

When she rose in the pride of her youth, she seemed to be moving apart,
As a single star in the South, self-limited, self-possessed;
But the law of the constellation was written deep in her heart,
And she heard when her sisters called, from the North and the East and the West.

They were drawn together and moved by a common hope and aim—
The dream of a sign that should rule a third of the heavenly arch;
The soul of a people spoke in their call, and Texas came
To enter the splendid circle of States in their onward march.

So the glory gathered and grew and spread from sea to sea,
And the stars of the great republic lent each other light;
For all were bound together in strength, and each was free—
Suddenly broke the tempest out of the ancient night!

It came as a clash of the force that drives and the force that draws;
And the stars were riven asunder, the heavens were desolate,
While brother fought with brother, each for his country's cause—
But the country of one was the Nation, the country of other the State.

Oh, who shall measure the praise or blame in a strife so vast?
And who shall speak of traitors or tyrants when all were true?
We lift our eyes to the sky, and rejoice that the storm is past,
And we thank the God of all that the Union shines in the blue.

Yea, it glows with the glory of peace and the hope of a mighty race,
High over the grave of broken chains and buried hates;
And the great, big star of Texas is shining clear in its place
In the constellate symbol and sign of the free United States.

IV

AFTER THE PIONEERS

After the pioneers—
Big-hearted, big-handed lords of the axe and the plow and the rifle,
Tan-faced tamers of horses and lands, themselves remaining tameless,
Full of fighting, labour and romance, lovers of rude adventure—
After the pioneers have cleared the way to their homes and graves on the prairies:

After the State-builders—
Zealous and jealous men, dreamers, debaters, often at odds with each other,
All of them sure it is well to toil and to die, if need be,
Just for the sake of founding a country to leave to their children—
After the builders have done their work and written their names upon it:

After the civil war—
Wildest of all storms, cruel and dark and seemingly wasteful,
Tearing up by the root the vines that were splitting the old foundations,
Washing away with a rain of blood and tears the dust of slavery,
After the cyclone has passed and the sky is fair to the far horizon;

After the era of plenty and peace has come with full hands
to Texas,
Then—what then?

Is it to be the life of an indolent heir, fat-witted and
self-contented,
Dwelling at ease in the house that others have builded,
Boasting about the country for which he has done nothing?
Is it to be an age of corpulent, deadly-dull prosperity,
Richer and richer crops to nourish a race of Philistines,
Bigger and bigger cities full of the same confusion and
sorrow,
The people increasing mightily but no increase of the
joy?
Is this what the forerunners wished and toiled to win for
you,
This the reward of war and the fruitage of high endeavour,
This the goal of your hopes and the vision that satisfies you?

Nay, stand up and answer—I can read what is in your
hearts—
You, the children of those who followed the wild bees,
You, the children of those who served the Lone Star,
Now that the hives are full and the star is fixed in the
constellation,
I know that the best of you still are lovers of sweetness and
light!
You hunger for honey that comes from invisible gardens;
Pure, translucent, golden thoughts and feelings and
inspirations,
Sweetness of all the best that has bloomed in the mind of
man.

You rejoice in the light that is breaking along the borders of science;
The hidden rays that enable a man to look through a wall of stone;
The unseen, fire-filled wings that carry his words across the ocean;
The splendid gift of flight that shines, half-captured, above him;
The gleam of a thousand half-guessed secrets, just ready to be discovered!
You dream and devise great things for the coming race—
Children of yours who shall people and rule the domain of Texas;
They shall know, they shall comprehend more than their fathers,
They shall grow in the vigour of well-rounded manhood and womanhood,
Riper minds, richer hearts, finer souls, the only true wealth of a nation—
The league-long fields of the State are pledged to ensure this harvest!

Your old men have dreamed this dream and your young men have seen this vision.
The age of romance has not gone, it is only beginning;
Greater words than the ear of man has heard are waiting to be spoken,
Finer arts than the eyes of man have seen are sleeping to be awakened—
Science exploring the scope of the world,
Poetry breathing the hope of the world,
Music to measure and lead the onward march of man!

Come, ye honoured and welcome guests from the elder
nations,
Princes of science and arts and letters,
Look on the walls that embody the generous dream of one
of the old men of Texas,
Enter these halls of learning that rise in the land of the
pioneer's log-cabin,
Read the confessions of faith that are carved on the stones
around you:
Faith in the worth of the smallest fact and the laws that
govern the starbeams—
Faith in the beauty of truth and the truth of perfect beauty,
Faith in the God who creates the souls of men by knowledge
and love and worship.
This is the faith of the New Democracy—
Proud and humble, patiently pressing forward,
Praising her heroes of old and training her future leaders,
Seeking her crown in a nobler race of men and women—
After the pioneers, sweetness and light!

HENRY VAN DYKE.

WAITING FOR THE SONS OF GOD

"For the earnest expectation of the creation waiteth for the revealing of the sons of God."—*Romans viii, 19.*

"For all creation, gazing eagerly as if with outstretched neck, is waiting and longing to see the manifestation of the sons of God."—*New Testament in Modern Speech.*

THIS morning we will make no attempt to reach the height of Paul's great argument. We will content ourselves with immediate, practical applications of his profound thought. His view, in a sentence, is that all animate and inanimate creation protests against the suffering which has been imposed upon it; that the universal longing for a better state and a better time is a prophecy of distant glory; that these sufferings are but as the birth-pangs of new and gladder worlds; that the universe was made subject to change, in hope that no evil thing may endure, that even Winter may change to Spring, and that love may conquer at the last. And the essential condition of the realization of this hope is the appearance of the sons of God—the appearance, that is to say, of good men and women. For this the creation, gazing eagerly as if with outstretched neck, waits and longs. The good time coming—which is always coming but never come—will be here: the prophecies will be accomplished fact; the radiant dreams of poets will be the plain prose of life; the creation itself will be delivered from the bondage of corruption—in proportion as the race produces men and women who are manifestly the children of God. What hinders the coming of God's kingdom amongst men? How hold we the heaven from earth away? What wait we for? We are waiting for more men and women heroic and

holy, generous and good. We are waiting for the sons of God.

This is the energy of all moral effort—a steady supply of good men and good women. This is the steam which makes the engine move. This is the stored up potency of electricity which lights up a city or drives the vast machinery of modern life. Do great men produce great ages? Or do great ages produce great men? These are questions which our Literary and Debating Societies have been arguing for a hundred years. Emerson would tell you that an institution is only the lengthened shadow of a man: Protestantism, of Martin Luther; Quakerism, of George Fox; Abolitionism, of Thomas Clarkson; Methodism, of John Wesley. All history resolves itself quite easily into the life stories of a few stout and earnest persons.

To-day we give God thanks for the Rice Institute of Liberal and Technical Learning. We praise the Giver of all good for the bright hopes which have gathered about these Dedication hours. We rejoice in the public spirit of the man whose name it bears, in his broad and generous views, his insight into our common needs, his prevision of the dawning greatness of this State, his love of the fair Southland. We bless God for the inspiration of a great and splendid purpose in the soul of the founder of this University; not less do we praise Him for the men who have given themselves with patient, self-denying, patriotic toil to the achievement of that purpose. Some have passed into the Unseen: some are with us to-day. One sows: another reaps: God be praised, Sower and Reaper rejoice together!

In the Rice Institute of Liberal and Technical Learning the seeing eye perceives an incarnation of constructive energy. From its halls and laboratories shall go forth men and women who are men and women indeed, trained,

equipped, fearless, aspiring, self-reliant, faithful to conscience and to God—the men and women for whom creation waits! Producing such streams of redemptive, life-giving power, the Rice Institute shall make for the worth and wealth, the health and happiness, of this old world. And happiness is a moral asset, never doubt it. Diffused amongst the masses of the people, it is an asset of incalculable value in the life of a nation. It is hungry men who make revolutions. It is what a British journalist has called "a mighty mob of famished, diseased, and miserable Helots" who menace the security of life and property in the midst of a wealthy civilization. Happy men and women are under no temptation to become anarchists. A honeymooning couple are in no mood to throw dynamite bombs at the palaces of the rich. Education, all the world over, in all the worlds there are and in all ages, is emancipation. It manumits and it edifies. First it frees the slave; then it builds the man. Capacity and culture—skill for the hand and sight for the soul—to open to the individual, man or woman, a means of living and the meaning of life—why, this is patriotism not less noble and ennobling than that of the heroic men whose praises our Laureate hymned yesterday, who

saw the many-million-acred land,
Won from the desert by their hand,
Swiftly among the nations rise,—
Texas a sovereign State,
And on her brow a star!

It is poverty, stupidity, ignorance, which do the devil's work. The world is cursed by ignorance and darkness. It will be blessed by knowledge and light. "Let there be light!"—it is the creative fiat. It thunders down the ages from the

dawning of the first morning of the world. And Jesus said, "Give them to eat!"

When with prayer and praise and in communion with the Highest we dedicate this institution to the advancement of Letters, Science, and Art, we dedicate it to the making of men and the making of nations. We dedicate it to America! It is our contribution to the stability of the social order, to the permanence of American institutions, to the propagation of the principles for which America stands in our modern world, to the perpetuation of the forces which called her into being and by which she lives. This is our gift to the greatness of our land.

For the forms of democracy are precisely those through which corruption most easily works if the spirit of democracy be lacking. What forces inhere in law and constitution and in the administration of law which may not be blown to the four winds of heaven upon the breath of some demagogue, drunk with the lust of place and power, most ignorant of what he 's most assured of, and like an angry ape playing such fantastic tricks before high heaven as make angels weep? This country was brought to birth under compulsion of the ideal. Heroes who poured their blood out for the truth, women whose hearts bled, martyrs all unknown, gave birth to our country and to its liberties. Its greatness goes back to the visionary and the seer; to the Jesuit missionary marching from the Atlantic to the Mississippi, to the Pilgrim and the Puritan of New England, the Lutherans of Pennsylvania, the Moravian missionaries of Ohio, and all the countless hosts of the obscure, the silent, and the dead who, living, believed in God and His goodness, and followed the gleam. What is to preserve in our modern life this ancient vigor of the spirit? What is to keep the soul of the nation alive?

On what grounds do you believe that this Republic will endure? No republic has yet endured as monarchies have done. Fifty years ago some of the most thoughtful minds in Europe were satisfied that this democracy could not last. During the Civil War the Prince Consort, Queen Victoria's husband, said, with a sort of sardonic satisfaction, "Republican institutions are on their trial." From that trial republican institutions emerged triumphant. You believe that the noonday splendor of this land will outshine the golden glory of its dawn. Whittier declared that the sons and daughters of the Pioneer should

Make the people's council hall
As lasting as the pyramids.

On what ground does this conviction rest? But on what grounds does your belief rest? Why should this Republic endure?

On the side of a current controversy it is glibly asserted that in the last analysis a State rests on force. The opponents of a popular movement go on repeating this dictum as though it were an oracle from heaven. A State rests on nothing of the kind. And force—by which is meant physical force—cannot keep a nation strong. Force could not save the Roman Republic. Rome possessed the finest army that has ever existed on the face of the earth. As a fighting machine it had attained unto perfection. And the Roman Republic failed. To-day Sir Edward Grey, Secretary of State for Foreign Affairs in King George's cabinet, has warned the British Parliament and the British people that if the insane rivalry of the nations in the matter of military and naval strength be continued, sooner or later it will submerge civilization itself.

The State does not rest on force. It rests upon confidence—a vastly different thing. The basis of our modern society is confidence in one another. You who know a thousand times more about it than a preacher possibly can, let your imagination play for a moment about the vast, far-reaching, apparently illimitable ramifications of commerce made possible between man and man. How much business did you do last year, and how much are you hoping to do next, upon guarantees not very much stronger than the word of a man of whom you know little, and the honor of corporations the individual members of which you do not know at all? The State rests upon confidence in the social order; upon our common trust in justice and in the administration of justice, in law and the sanctity of law. And if the objector says, "Yes; upon the knowledge that force can be used to secure the due observance of law," the answer is easy: "You have not carried your analysis far enough." Our confidence is not grounded in the conviction that the State can control and direct physical force, but in the conviction that the force of the State will in the long run be controlled and directed by wise and good ends. That is to say, the strength of states is in the fundamental rightness of our human nature and our undefined belief that the mass of mankind would rather do right than wrong. The material wealth of cities, the integrity of states, the happiness of kingdoms, the greatness of a republic, alike go back to this, to the number of good men and women they can produce. All creation—all creation we know, Houston, Texas, the South, America, our modern civilization—gazing eagerly as if with outstretched neck, is waiting and longing to see the manifestation of the sons of God.

We have felt the lack of this driving power in the machinery of our social and political life. We have missed the note

of moral enthusiasm. The touch of a high spirit upon human affairs has been wanting. We seek the compulsion of commanding genius and character. Such a voice as that which once from Gettysburg all fragrant with the memories of a nation's dead, shook the civilized world, is heard no more. Our big men are not big enough. Our leaders are too far in the rear of those they lead! We are ready to cry out again with the poet—prophet of two democracies:

O for an hour of that undaunted stock
That went with Vane and Sydney to the block!
O for a whiff of Naseby, that would sweep,
With its stern Puritan besom, all this chaff
From the Lord's threshing-floor!

For our conviction is that deep down in the hearts of the people there is a capacity for being led; that the people who are being led wrong could be led right; that however corrupt interests deceive, fool, and use the people, there is still that in a nation which might be called the soul of a people; and a soul which would wake at the call of a son of God. *Men* are there, but *Man* is missing. And like our wild-eyed Hosea Biglow, with his tongue of truth and heart of flame, we feel—

More men? More man? It's there we fail;
Weak plans grow weaker yit by length'nin':
Wut use in addin' to the tail,
When it's the head's in need o' strength'nin'?

We wanted one that felt all Chief
From roots of hair to sole of stockin',
Square sot with thousan'-ton belief
In him and us, ef earth went rockin'!

We are waiting for this Man, with the thousand-ton belief *in himself* and in us, in Righteousness and God, who will give expression in consecrated and consecrating action to the social aspirations of a million hearts. We are waiting, in the high places of the land, for the sons of God.

That is not all. Let us come to something even nearer to hand. Upon the work of this institution and of institutions like this depends entirely the question whether our amazing material resources, our ingenuity, our inventiveness, our science and skill, shall prove a blessing or a curse. A person or a community may find the disadvantage of possessing so many advantages. We may be ruined by our prosperity. We glory in the best equipment which skill and science can devise; but there is not one thoughtful person here who has not known individuals who would have been better equipped for their work if they had not been equipped so well! One is haunted by the fear that in our day and country we are not producing results commensurate with our efforts. In proportion to the extraordinary increase of our resources, are we doing the good in the world we ought to do? In the world of art and science are we, with all our wealth of training and equipment, doing relatively greater work and better work than, let us say, George Stephenson, the inventor of the locomotive, when he taught himself arithmetic on the sides of colliery wagons, or Wilkie when he learned painting with a piece of chalk and a barn door, or West when he made his first brushes out of the cat's tail; than Watt, the inventor of the steam-engine, when he made his first model out of an old syringe; Humphry Davy, of safety-lamp fame, when he extemporized his scientific appliances from kitchen pots and pans; and Faraday, described by Sir William Ramsay last Friday as one of the most brilliant physicists and most daring experimenters of the nineteenth cen-

tury, when he made his from glass bottles; or better work and greater than when Elihu Burritt mastered eighteen ancient and modern languages while shoeing horses at the village forge?

We are doing better and greater work, you are confident. And you name Mr. Edison and Signor Marconi. But, relatively to the wealth of our resources, is the result all it should be?

In the world of moral effort are you quite so confident? Stephen, the first Christian martyr, John Ruskin reminds us, did not get bishop's pay for that long sermon of his to the Pharisees. He only got stones. And Paul had no cathedral called by his name from which to preach his Gospel to the Roman world. When Augustine and his monks landed at Ebbsfleet and met the English king between that place and Canterbury, and declared the good news of Jesus to him, there was no missionary society and missionary press behind him. When the famous few met in a house at Kettering to win heathenism for Christ, the first collection was sixty-six dollars. Do you not think that we ought to do vastly more with our wealth and numbers than men did who were few and poor? Yet are we in the way of accomplishing more for the age we live in and for ages to come than Stephen did for the Jewish world, Paul for the Roman world, Augustine and his monks for the English world, and Fuller Pearce and Ryland for the world of the distant East?

We are not gaining all we ought to gain from the resources that are ours. Why? We leave the work to the machinery, when we ought to do it ourselves. This nation has developed a capacity for organization which is as unmistakably an inspiration of genius as the sculpture of Pheidias or the philosophy of Plato. The art of the Greek, the law of the Roman, the Hebrew passion for righteousness,

the genius of the English for colonization, is not more characteristic nor more significant in the evolution of the race than the genius of the American people for organization. But such high and notable qualities have their natural defects. In this country we first make the machine, and then we bow down and worship it. We kneel and say our prayer to it: "Almighty and everlasting Machine, we beseech thee to roll over us, crush down our insurgent will, and grind down our souls to a pale unanimity!" But neither an individual nor a nation can be better than the gods it worships. If we first make our gods and then worship them, we end by becoming like them. We worship the machine—and we become machines! We have lived to see the apotheosis of the filing cabinet. When Gambetta was praised by a friend for what was perhaps the greatest speech of his life he said, "For seven years I have wanted to make that speech. I have had it here (the heart), but I have not had it here (the head)!" With us, he would only have had to look under A B C, or perhaps under X Y Z, and he would have found it all in the card index!

Our religious work is hag-ridden by this superstition of the machine. The worst speech I have heard in more than five years of residence in this country—always excepting my own, but those I forget—was on "The Standardized Church." Every Church was to be raised up and leveled down and sawn off lengthwise and chopped across and planed superficially to a standard which existed in the machine-made mind of the standardizer. Somewhere in the broad heavens, he seemed to think, there is an everlasting stencil, and with every sweep of the cosmic brush a million souls are produced, all made to measure! The gifted organizer wears himself to a shadow in his determination to standardize the world; and one prays for him the cure which

William III, king of England, desired for the victim of a contemporary superstition. He was the last king of England who practised what was known as "touching for the king's evil." When kings ruled by divine right—what Byron called "the right divine of kings to govern wrong"—it was believed that the touch of one of them would cure a certain disease. They brought a sick man to bluff William; he laid his hand on the sick man's head and said, "May the Lord give you better health and more sense!" But we go on discussing methods—methods—methods!—methods of Sunday-school work, of Church work, of Missionary work—the underlying assumption being that there is one correct, complete, absolute, and universal method, and if only we could find it the work would get done of itself! I sat in a Missionary Conference where godly old women of both sexes discussed "methods." And a missionary just home from the Congo whispered to me, "I have been flat on my back while a naked savage about six feet six inches high, and as tall across, had his foot on my chest and his spear at my throat. What sort of a missionary method ought I to have used then?" To be sure! There are just as many methods as there are men and women. There are just as many good methods as there are wise and good men and women. There are just as many bad methods as there are foolish and lazy men and women!

Henry Ward Beecher once went through a factory equipped with the most perfect machines produced in his day. He gazed on them with admiration, and after a long and lingering gaze he said, "They look intelligent; I think they ought to vote." One has heard something somewhere about the machine voting, but that is neither here nor there! A machine may look intelligent, but "intelligent" is precisely the thing which it is not. All your machinery needs intelli-

gent men and women to work it. Organization is a necessity; but there is danger even in a necessity. The danger is that we leave the organization to do what can be done only by a living spirit. It is the tendency of all human organizations to stifle individuality. Let the organization follow its own tendency and it droops and dies. It is for the individual to assert himself within the organization and, if need be, against it. By so doing he serves its interest and saves its life. Force and Fire brought the organization to birth—Force of Will and Fire of Devotion. By Force and Fire alone can it be fed and nourished into vigorous life—Force of Character and Fire of Love. The organization is a magnificent piece of machinery. But no mechanical means at present known to mortals will generate energy to set it working and keep it going. Human heart-beats must supply the driving power. The Apostle Paul is right: we are waiting for the sons of God.

"The Rice Institute of Liberal and Technical Learning"—is it so the name of our institution runs? "Liberal and Technical Learning": what I have lately called "Skill of hand and sight of soul"—it is a superb challenge to brain and heart. It was expounded yesterday by the President in a speech entirely noble, the chaste language worthy of his lofty theme. I will not go over the ground again, and do badly what Dr. Lovett did so well. But let me set his conception, which is my own, in the light of religion, and test it by its proved capacity to satisfy our human needs.

In the world of moral effort we meet the Idealist whose sublime head strikes the stars—and who tramples human hearts beneath his feet. He lifts up his eyes above the mountains, and he does not know of any healing ministry for the devil-haunted child in the crowded street. The Corn-law rhymer in England more than sixty years ago described

a type of philanthropist with whom our generation is scarcely less familiar:

Their noble souls have telescopic eyes
Which see the faintest speck of distant pain;
While at their feet a world of agonies,
Unseen, unheard, unheeded, writhes in pain.

With better intentions and purer life, the Idealist may yet fritter away his strength in endeavor as futile.

But in the world of moral effort we still meet more often the person who thinks himself practical and takes pride from his belief. He will not look to the far-off interest of tears; no, not he! He is not going to sow the seed and wait for after ages to reap the harvest. He tells you that he wants results. He wants crops. He wants to get there, and to get there quickly. He is the get-rich-quick man of the world of altruism, philanthropy, and reform. If he is called to preside over the councils of a great nation, the best you can say of him is that he is an extempore statesman, a statesman trying to set the world right by rule of thumb, profoundly ignorant of the nature of the forces with which he is playing, and proudly indifferent to the age-long, world-wide consequences of his acts. This is the best you can say of him—if you are a patient and sweet-natured person; but if you are not—why, you say something worse. A man may mean well. But men and institutions and nations need to avoid the devil's short-cuts to a desired end.

What then? The Idealist may be a failure and the practical man a fool. What we want is the practical man who lives by the power of the ideal. Often he has to work almost in the dark; slowly he gropes through the broadening dawn. But he sees the light and whence it flows. And he

knows that each steady step is toward the rising sun. He has certain principles. They may be few. But they are sufficient. They are clear-cut, firm-rooted, four-square to all the winds that blow; and they are safe. He knows, as the world knows, that this same world is not ready to apply those principles immediately and universally to the whole round of human conduct. But he knows, what the world does not, that these are the principles by which alone men live, and that the nations which will not adopt them God sends down to destruction. He, too, is an Idealist of the purest type; but he will labor night and day to apply his principles where and when he can, winning from the unprincipled, anarchic world here a little, there a little, and every little looking to the one far-off divine event to which the whole creation moves. Do you tell me that he is living in each little act, each little step, each little gain of justice upon injustice, each day's work well done? I tell you, No! He is living in the true, the good, and the beautiful. He sees life, and sees it whole. He is living in the march of deathless generations. He is living in the sweep of the ages. He is living in the triumph of immortal principle. He may tell you, with his rough practical senses alert and his ear to the ground, that he has only to live one day at a time; but he knows, though he keeps the knowledge to himself, that really and truly he is living in eternity—living, that is to say, in principles older than protoplasm, causes that complete and crown the centuries, and movements that roll back the tide of guilt and sin.

Yesterday, with joy and deep thanksgiving, the Rice Institute was dedicated to the purpose set forth in its Founder's will, in the presence of those whom Dr. van Dyke called the

Honoured and welcome guests from the elder nations,
Princes of science and arts and letters.

Now we, the people of Houston and of Texas, rise and solemnly link ourselves to that consecrating act. We dedicate this institution to the advancement of Letters, Science, and Art, to the service of the imperial commonwealth of Texas; to the material and moral progress of the Southland; to the cause of human improvement over all the earth; and to the greater glory of God. Upon President and Trustees and Faculty, upon other great-hearted men and women who shall bring to the aid of this institution, now and in the coming days, gifts of heart and brain and hand, we invoke the benediction of the Most High. And earnestly we pray that in the years to come the sons and daughters of the Rice Institute may bring honor to its name; that their children and their children's children may rise up to call it blessed; that they may show themselves to be the Sons of God for whose coming Creation waits and longs, co-operating with the world's eternal purposes and preparing for a redeemed humanity a renovated earth.

CHARLES FREDERIC AKED.

EDUCATION AND THE STATE

THE importance of the dedication of the Rice Institute is emphasized by the presence of so many distinguished scientists from other nations and by the presence of distinguished educators of other States of this Union. The interest which prevails in Texas, and especially in this city, in the future of this university, is manifested by the assemblage which is before me. But of equal importance are the provisions made by Mr. Rice to secure the success of the enterprise by placing it in the hands of such able trustees, who can be relied upon to use the funds to the best advantage. These buildings, so well adapted to the work to be done, and especially the competent president and his assistants selected to execute the provisions of the will, give additional assurance of the wise application of the beneficent donation to the education of young men and women of Texas.

The American population in the State of Texas revolted against the Mexican rule, and on the second day of March, 1836, published a declaration of independence, specifying the causes which justified the act, one of which was expressed in this explicit paragraph: "It has failed to establish any public system of education, although possessed of almost boundless resources (the public domain), and although it is an axiom in political science that unless a people are educated and enlightened it is idle to expect the continuance of civil liberty, or the capacity for self-government." The Constitution which was adopted by the people of the Republic in its General Provisions, Section 5, reads: "It shall be

the duty of Congress, as soon as circumstances will permit, to provide by law a general system of education."

The Constitution of the State of Texas, adopted in 1845, expressed the same purpose in terms thus: "A general diffusion of knowledge being essential to the preservation of the rights and liberties of the people, it shall be the duty of the legislature of this State to make suitable provision for the support and maintenance of public schools." That provision was repeated in 1866 by the convention which reformed the Constitution of the State so as to conform to our new relations to the Federal Government. The Constitution of 1876, now in force, contains like provisions, and to secure its enforcement the convention set apart certain classes of lands and taxes for the maintenance of a system of public free schools. On every appropriate occasion the people of Texas have expressed their purpose to make ample provision for the maintenance of an efficient system of public free schools in this State for the education of the masses.

Prior to the war between the States, the people were dependent for the education of their children upon private schools organized and supported by the patrons, each paying tuition to the teacher. The consequence was that those children whose parents were unable to pay and orphans who were indigent were not provided for. The teachers of those schools were usually men, and, as a rule, were better instructors than now employed in the public schools of the country districts.

The purpose to inaugurate free schools survived the war between the States, and during the administration of Governor Davis free schools were organized to some extent, but had little success until the adoption of the Constitution of 1876; since which time much progress has been made and the public-school system is much improved, especially in the

cities and towns. The State University, the Agricultural and Mechanical College, and a number of colleges of good capacity supported by the State afford to students good opportunity for higher education. Austin College, Baylor University, and the universities of the different churches constitute a valuable auxiliary educational force with which Rice Institute will take its place as a part of our system of higher education, and no doubt the Institute will be a creditable accession thereto.

I have briefly reviewed the history of educational institutions in Texas to point attention to the fact that public sentiment is ready to welcome the Institute, and the provision for education in this State, public and private, is in condition to promote success.

I am not informed as to the date of Mr. Rice's settlement in Texas, but it was in the life of the Republic, and he imbibed the spirit which prompted the declaration in favor of education, above quoted, and which survived the years of an active life and prompted the provision made for this Institute.

Mr. Rice was a young man, with no capital except his manhood and his intellectual and moral endowments, when he became a citizen of the Republic, and by his industry and economy acquired a large fortune. He held public office and participated in the public enterprises of the community in which he lived up to the date of disqualification by infirmity. He was prominent in the upbuilding of the City of Houston, and in the construction and operation of railroads by which the whole State was benefited. In fact, he was an important factor in the development of Texas, and by this donation expressed his appreciation of the favors he had received and the advantages offered to him, which is creditable to his memory.

In order to comprehend the full value of the endowment of this institution it is necessary to look to the condition of the State and the needs of the people who will be indirectly benefited by its work; for it is true that the greatest value will accrue from the lives and labors of those who may be educated here, and will be enjoyed by many who will not recognize the fact that it is traceable to this university, but that fact does not detract from its importance.

If the benefits to be derived from this institution be confined to those persons who may receive instruction here and to the financial benefits accruing to the City of Houston, Rice Institute would be worth all that it will cost. But, in fact, such individual and local benefits will be a small part of the total good that will accrue to the people of Texas from this liberal donation. The Institute is located at Houston, but it belongs to the whole State. The arts and sciences are made special subjects of instruction, and they who acquire the knowledge of these branches of learning will go forth to put into practical use the knowledge thus obtained, with a purpose to acquire fortune or fame for themselves, but such persons will necessarily have good or evil influence upon others. "No man liveth to himself." Through its students every institution of learning exerts a power for good or evil upon society, therefore the instruction given and the character of the institution itself are of importance to the public.

The greatest benefit derived from such teaching is the relief that comes to the unlearned masses, through the invention of new methods of performing their labor, relieving the laborer of the tax on his physical strength and increasing the return derived from it. The great progress made in the different industries has had its origin and consummation in the scientific knowledge of men, students of natural laws.

Bear with me if I am tedious, but I can better present by

illustration the fact that the greatest benefit of such training as will be received in this institution does not consist in the money accumulated or the fame won by the use of training received in such an institution as this. The history of the United States, and especially of Texas, shows a wonderful development and great amelioration of the drastic methods that taxed the energies of the pioneers, which have been effected by discoveries of methods of labor and the application of new powers.

To illustrate. Father removed from Jasper County, Georgia, to Washington County, Texas, in 1846. We saw our first railroad track and train at Atlanta, Georgia, and did not cross another railroad on our journey, which was made in wagons and carriages drawn by horses and mules, consuming three months' time. There was then no railroad in Texas. In 1851 father was farming on Mill Creek, west of Brenham, in Washington County. All family supplies were enormously high: flour was sold at fifteen dollars per barrel, and other things in proportion. We usually had biscuit for breakfast on Sunday mornings and at the preacher's visit. All merchandise was so exorbitant that the people were compelled to deny themselves such things as were not absolute necessities. The produce of the farm being conveyed to market on wagons, and their supplies being hauled by like conveyance to the interior towns, the consumers necessarily paid heavy freight charges. The construction of railroads has worked such changes that it would be difficult for one who has had no experience of those conditions to realize the great benefit that railroads have brought to the masses.

In my boyhood I saw a man lying near a tree appearing to be dead. The tree had been struck by lightning and the man had been shocked. He had taken refuge under the

tree from a rain-storm. In that day electricity was known to the people only as a dangerous element beyond human control. It has by scientists been converted into an important servant, doing various important things, as the telegraph, which bears the messages of men in all kinds of business, also the telephone, which without regard to distance enables us, for business or pleasure, to converse as if standing face to face.

In the days of the best mail service a letter sent to one in New York would not be delivered and answer returned for many days, perhaps weeks. The telegraph wire now transmits such message and brings a reply in a few hours. The telephone carries the voice, and enables one to speak to another hundreds of miles distant, and in a known tone of voice to receive a reply as if the parties were in the same room. The wireless telegraph seeks the vessel in distress, or person whose locality is unknown, with messages of relief. Electricity has in many ways proved to be a very potent and valuable servant to man. My proposition is, that the relief to the masses in these minor matters, each insignificant, has conferred more important benefits in the aggregate than the acquisition of much wealth by the inventor or persons who put those inventions and discoveries into operation.

The wonderful development of the natural resources of nature has been accomplished through scientific knowledge by persons trained in the sciences, and is the fruit of training received in such institutions as this. Therefore, I repeat that the relief which is conferred upon the laborers in making less burdensome their tasks, and the conveniences which have through this source come to men of business as the fruits of learning imparted to students by such institutions, are of paramount importance.

Within the last century both steam and electricity have, by scientific knowledge, been converted into the greatest powers the world has ever known. In fact, those powers now move the machinery of the world. I need not specify the particulars of their uses. Without them stagnation would reign in every department of life.

I have given but a very limited statement of the advancement in all grades of life and all classes of business, but it will suffice as a basis for my conclusion, that the development and progress of the world has been the result of scientific knowledge, whereby the laws of nature have been utilized for the benefit of man.

The training of men and women mentally or morally is not limited in benefit or injury to the individual trained, but each student who may be educated in this institution will affect the public for good or evil. If the training in the arts and sciences produces an inventor of machinery or one who applies to practical service an invention by another, it will be a benefit to all whose labors may be made lighter or whose earning power may be increased thereby.

I have used the illustrations of the application of steam and electricity to the service of man as a basis for my concluding proposition, that the development of the resources of nature and the advancement of mankind intellectually and morally have been due mainly to the discoveries by scientists of the laws of nature, whereby the labors of men have been relieved of much hardship, their ability to produce enlarged, and the conveniences of life greatly increased. If we consider the labors of the farmer, the new machinery multiplies the powers of the man and relieves the laborer of the great hardships which formerly attended the work. In every department of life we find the contrast between those who avail themselves of the discoveries of new methods and

those who still are unable to secure the benefits, from which we get some conception of what scientific discoveries have done for men.

The desire for higher education is increasing, and the universities and colleges of the State and of the Christian denominations are overtaxed. There is room for this institution, and ample work for it to do. Its field of usefulness is commensurate with the growing State, and it will be a Texas University dispensing to our ambitious young men and women the benefits of Mr. Rice's bounty. The people of the entire State welcome Rice Institute as more than a local school, and I assume to say for them, "God speed Rice Institute in its noble work!"

THOMAS JEFFERSON BROWN.

THE CHURCH AND EDUCATION

IT is a great privilege to be permitted to participate in the exercises attendant upon the opening of this great Institution. For, as we survey these noble buildings and recall the story of the Institute; trying to realize the extraordinary and almost unparalleled efforts of the President and Board of Trustees to study and profit by the history and results of educational enterprise and advance in every civilized country; the broad and lofty ideals, to which the work of the institute has been thoughtfully and deliberately consecrated, and the magnificent financial endowment at their disposal to reduce these ideals to practice;—we must indeed feel that we are here to-day witnessing and creating an epoch in the history of education, not only for the people of Texas, but for all Americans. I can only say that I pray God that the future usefulness of this Institute may be commensurate with the brave and wise and munificent provision of its Founder; and that in the years and decades and centuries to come the name and memory of William Marsh Rice may be called blessed by the thousands of good American citizens who shall have been the beneficiaries of his princely generosity.

I have come here, at the invitation of President Lovett and the Board of Trustees, not merely as a private citizen, not as the representative of the University of the South, of which I happen to be Chancellor, but as a representative of the Christian Church, to speak on the general subject of the Church and Education.

The two words are not accidentally associated. From the beginning Christianity has been an educational religion, and from the beginning has invited and encouraged intellectual

inquiry. Its first great missionary was a man of learning, a brilliant student of the Rabbinic Schools, the Apostle Paul; and St. Luke in the Acts of the Apostles praises the people of Berœa because they were more noble (*eugenesteroi*) and showed their nobility by listening to new opinions with readiness of mind, taking the trouble to examine whether they were consistent with what they knew to be the truth. As we read the history to-day we can understand why through such slow processes of preparation this innate spirit of liberty had to express itself. The early Christian Church found the classic literature of Greece and Rome filled with fables and deceits, and foul stories of the gods, which were calculated to injure both the faith and morals of a simple people, too unsophisticated to read them merely as literature; and therefore there appears very early a growing prejudice against pagan learning. But in spite of this fact, and in spite of the fact that the persecution of Christians up to the beginning of the fourth century bred in them a distrust and dislike of heathen books,—yes, in spite of the fact that the moral and social riot which accompanied the decline of Roman civilization created a reaction in favor of Christian asceticism and monasticism, which declared its hatred of the common world and everything connected with it,—its culture and refinement and learning, as well as its falseness, its cowardice, and its degradation,—in spite of all these temptations, these propulsions towards barbarism, the Christian Church became and continued to be the home and nursery of intellectual culture.

There is no name, for example, of any race or people in the third century comparable to that of Origen, the great Christian critic, the great Christian scholar; and the intellectual power and activity of Chrysostom and Basil and the Gregories, and Jerome and Augustine in the fourth and fifth

centuries,—all of them Christian teachers,—would shed glory upon the history of any nation in any age. It is the fashion, I know, with unfriendly critics to emphasize the ignorance and lack of education in the so-called dark ages: but even then there were many instances of Christian enthusiasm for liberal learning. The Benedictine monasteries were the storehouses of ancient manuscripts. The schools of Charlemagne, under the great Christian teacher Alcuin, were undoubtedly the foundation of the later university system of Europe. The British and Irish missionaries, sheltered from the wars that desolated continental Europe, were men of wide culture and enthusiasm for education. King Alfred the Great in England, a true scholar and the father of English prose, got his learning from the Church's schools.

Let us frankly admit all that the critics say: that the episcopal or cathedral schools, and the monastic schools, which represented practically all the educational effort of the Middle Ages, fell far short of popularizing real education or love of learning; and that the fact that there were in every generation some teachers and some schools which had a broader outlook does not redeem the ninth and tenth centuries, under the sway of the Christian Church, from comparative ignorance and barbarism. Yet, after all, it was the Christian Church which in those stormy and tempestuous times preserved the tradition and the materials of knowledge. If ignorance was wide-spread, there was good reason for it. The Church wrought and fought for four hundred years to justify and establish a new ethical ideal; and that is worth more to us to-day than any technical learning. Even in our time, when we study conditions in our cities we are obliged to admit that there are worse things than illiteracy. The Church was fighting the gigantic enemies of human civilization, and it was no wonder that she postponed her

battle with mere ignorance. That was comparatively a small thing. In the sixth and seventh centuries the barbarian hordes were pouring into southern Europe, and the only organized resistance to them was the Christian Church. As Guizot says, it was not merely Christianity as an influence, a doctrine, that saved Europe: it was Christianity as a Church, as an institution, that prevented human civilization being set back four hundred years. In the ninth and tenth centuries the Normans were invading Europe, the Danes were descending on England, the Saracens were threatening Christendom, and organized human society was fighting for its life. Elementary morality, the ten commandments and the Lord's Prayer, were of infinitely more importance than the study of Homer and Virgil, or even of the names of the birds, the fishes, and the trees.

And when peace at last did come for a season, it was out of a Christian school that men like Anselm went forth to assert the claims of reason and arouse the higher intellect of Europe to activity. With the age of Anselm, and largely through the work and thought of Anselm, archbishop of Canterbury in the year 1100, the historians of educational advance place the rise of universities and the beginning of that enthusiasm for knowledge which we commemorate to-day. As one of the modern experts on the history of education, Dr. Laurie, says: "The universities may be regarded as the natural development of the cathedral and monastery schools." We know anyhow that the Church is the real founder of the Universities of Paris and Bologna and Prague and Oxford and Cambridge; and in more recent times the same may be said of the leading universities of the United States. There are no words strong enough to express the debt which liberal learning and higher education owe to the Christian Church. It was the Great Head of

the Church Who said: "Ye shall know the Truth, and the Truth shall make you free"; and men like Agassiz and Romanes and Pasteur and Lord Kelvin have splendidly demonstrated that the greatest triumphs of the human mind, in scientific discovery and research, have been inspired by loyalty to the Divine Master, Jesus Christ.

Every day I live I am more and more convinced that the true incentive and justification of scientific effort to learn the secrets of this world in which we find ourselves is the fact of our relation of kinship to the good God, Who made and sustains it all, a relation which was revealed and certified to us by the Incarnation.

And this is why Christianity brought with it a new educational impulse to the world. It introduced into the life of our race new and fruitful ideas, which, working slowly perhaps as we count time, but surely, have created whatever is best in our modern civilization. It deepened the sense of brotherhood, gave it a wider meaning and a Divine sanction. At the same time it developed and emphasized the personal freedom and the personal responsibility of the individual man and woman, by teaching them that they are in a true sense children of God, born of God and destined to return to God. Yes, it wove the hope of immortality into the common thought of daily life, and justified higher learning and research for their own sakes, by declaring that every bit of progress that man makes in knowledge and character has value and significance beyond time and forever.

Christianity taught the worth and importance of the individual, the necessity of his effort for self-development and self-expression, as it had never been taught before: but it also emphasized the purpose and meaning of this self-development as increase of efficiency for service—service to God and to our fellow men. And thus it invited and challenged the

world to the realization of an ideal of eternal value, an ideal which a thousand thousand years of educational experiment will not exhaust or overpass, an ideal which consecrates all man's intellectual effort, justifies all his unwearied search for knowledge, and holds before him an ever-vanishing goal of perpetual pursuit; and that Christian ideal is the development of the utmost efficiency, physical, mental, spiritual, in every individual man, woman, and child, for the sake of mutual service in the Kingdom of God.

I have ventured upon this brief and imperfect sketch of the historical attitude of the Christian Church towards education in its intellectual aspect, first of all because not a few writers and speakers, prejudiced by superficial accounts of the Middle Ages, and obsessed with the importance of mere mental development, have done injustice to the Church, not caring to consider that it was the Church's moral conquest of barbarism that created the atmosphere and environment which enabled modern physical science to begin its work.

Who loves not knowledge? Who shall rail
Against her beauty? Who shall fix
Her pillars? Let her work prevail.

But what is she, cut off from love and faith,
But some wild Pallas of the brain
Of demons, fiery hot to burst
All barriers in her onward race
For power? Let her know her place:
She is the second, not the first.

But secondly, I have insisted upon the Church's ideal at the opening of a great institution like this, because I want to

plead with this audience for a recognition of the claims of patriotism.

The Rice Institute will last, we hope, for centuries to come, provided that the American people continue to maintain and reverence those moral ideals of life which create the quality of manhood and womanhood that makes free government secure. For the true end and aim of education is to develop men and women, and not to make machines or tools. A man may be so trained as to become a very successful machine for making money, or a keen-edged tool for others to use in exploring and producing material wealth; but such products of the schools are very often poor citizens, and worse husbands and fathers.

Of course I realize that if life for each one of us means simply to "make good," as the phrase goes, for our generation, getting what comfort and ease and luxury we can by plan and effort and struggle in the present time; taking advantage of whatever social, commercial, or political condition may conduce to our individual advantage; opportunists in conduct and pragmatists in philosophy; having no thought for the future, or interest in the success or failure of the Republic, or the happiness or misery of the generations that are to come after us;—I realize that if this be our life's philosophy, then of course the measure of the value of an institution like this is the amount in dollars and cents which its students shall be trained, not necessarily to earn or deserve, but to get, to acquire, to gain.

But I have not so understood the plan and scope of this Institute, or the ideals and hopes of the men who are on its Board of Administration and compose its Faculties.

Surely this Institute stands for higher and better things than mere materialism and commercialism. While, indeed, it must be conducted according to the most approved princi-

ples of scientific method and theory in order to promote the practical efficiency of its students from every section, yet it will, we hope, also give room and encouragement to that loftier human aspiration which we call liberal culture, and strive to create and nurture that enthusiasm for real learning which has made the finest and truest progress of our race.

For I hold that it is not the men of action, whether on battle-fields or in cabinets or in commercial business, that have most truly helped the world. Nor is it the men who have invented new tools and new machinery, and discovered new methods of utilizing Nature's forces for man's use and comfort, and for the increase of material wealth, who have been the foremost benefactors of mankind. Rather it is the men who with moral heroism and unwearied love of truth for its own sake, asking no recognition and no reward, have tried to create through schools and colleges and universities an atmosphere, a tone, a *Zeitgeist,* that will inspire men, in spite of themselves, to noble aims; aye, it is these men who by their very retirement and isolation have escaped the contagion of current fashions of thought, whose humility is the result of long experience of the difficulty of arriving at absolute certainty on any subject, and who by patience and faith have found for themselves, and are working to protect and defend, a height, whence he who will may attain their vision —the vision of a larger world and a greater life.

This is the true measure of the scholar; this is the justification of the University. And this means religion; that a man is not a mere brute, nor a unit of sensation, but the child of God, akin to God, with capacity for infinite happiness and responsibility for infinite progress. And in this definition of education all true learning, all advance in real knowledge, has a religious value. The search for truth is itself a re-

ligious act; and the men who, honestly and sincerely, are studying and teaching Nature's secrets are the servants of the Most High God.

Let us accept this as the Divine Message, the Divine Challenge, and the assurance of the Divine Blessing to this Institute. Truly it may be said of it, that it has been founded as securely as the wit and knowledge of man can plan, with financial support assured to it, in extent almost unequaled in the history of educational institutions. If only it will take its stand for God and His righteousness, then indeed may we apply to it the words of the Prophet:

"I will lay thy stones with fair colors, and lay thy foundations with sapphires. And I will make thy windows of agates, and thy gates of carbuncles, and all thy borders of pleasant stones. And all thy children shall be taught of the Lord, and great shall be the peace of thy children."

THOMAS FRANK GAILOR.

THE MEANING OF THE NEW INSTITUTION

I

THE FOUNDATION: ITS SOURCE

IT is a common saying in drawing-room and market-place that we are living in a wonderful age. Perhaps no known period of the past towers up to it, unless it be the age of Pericles, or that in which the Roman Empire was consolidated, or that of the Reformation. No features of the age are more striking than the handsome foundations which have been provided by private donation for lengthening the days of man and enlarging the content of his spiritual life. Every child of ten years knows the names of Alfred Nobel and Cecil Rhodes, of Mr. Carnegie and Mr. Rockefeller, of Girard and Peabody, of Johns Hopkins, Leland Stanford, and Cornell: the names of these gentlemen are household words, and in thousands of American homes their bearers have become household gods.

In this charmed circle of immortal philanthropists the name of William Marsh Rice is permanently inscribed this day by the poet of Princeton, the jurist of Texas, and the bishop of Tennessee. Thanks to the inaugural lectures of those twelve prophets of the fundamental sciences, the liberal humanities, the progress of modern learning, Altamira of Madrid, Borel of Paris, Croce of Naples, De Vries of Amsterdam, Jones of Glasgow, Kikuchi of Tokyo, Mackail of Oxford, Ostwald of Leipsic, the lamented Poincaré of Paris, Ramsay of London, Størmer of Christiania, and Volterra of Rome, the good-will of Mr. Rice to open new

springs of inspiration and living fountains of knowledge in an institution of liberal and technical learning becomes known to the world of letters and science and art, to whose advancement he gave of his substance and of his life.

For this fair day we have worked and prayed and waited. In the faith of high adventure, in the joy of high endeavor, in the hope of high achievement, we have asked for strength, and with the strength a vision, and with the vision courage: the courage born of straight and clear thinking, the vision of enduring forms of human service, the strength in resolute and steadfast devotion to definite purpose. And to-day, by virtue of the founder's splendid gift to the people, by virtue of the public spirit of his early advisers, by virtue of the public service of those who defended his last will and testament and thereby protected the people's rights, by virtue of the covenant which his trustees have kept in all good faith and conscience, by virtue of the constant creative work of supervising architects and the arduous labors of constructive engineers, by virtue of the cheer and the criticism and the counsel of friends in the community and throughout the commonwealth, the Rice Institute which was to be, in this its modest beginning, now has come to be—the new foundation has accomplished in its own being the miracle of all living things: it has come to life, and from this day forth takes a place, let us hope of increasing influence and usefulness, among those institutions which have made possible the civilized life of men in communities of culture and restraint—the State, the Church, and the University.

There are men and men and men. There are men of millions and men of millions. William Marsh Rice was a man in a million, an inspired millionaire who caught the prospect of monumental service to Houston, to Texas, the South, and the Nation. With no resources other than soundness of

body and strength of will, from a New England home of English and Welsh forebears, he came to Texas in his youth to make his fortune. By temperate habits of industry and thrift he made a fortune in Texas. He left his fortune in Texas. He gave his fortune—the whole of it—to Texas, for the benefit of the youth of the land in all the years to come; thus writing in the history of Texas the first conspicuous example in this commonwealth of the complete dedication of a large private fortune to the public good. Moreover, resolutely living a simple life, he denied himself even the "durable satisfaction" of seeing his philanthropy's realization in order that he might give more abundantly of life to his fellows and their successors. Shrewd in foresight, strong in purpose, of stout courage and independent spirit, generation after generation will rise to call him blessed—"with honour, honour, honour, honour to him, eternal honour to his name."

II

THE FOUNDATION: ITS SITE

TO his trustees, a self-perpetuating board of seven life members, the founder gave great freedom in the interpretation of his programme and corresponding discretion in the execution of its plans. The charter and testament under which these gentlemen discharge the obligations of their trusteeship are documents so liberal and comprehensive as to leave the institution under practically but one restriction, namely, its location must be in Houston, Texas. But therein lies what is perhaps its greatest opportunity. For men who are too busy doing the world's work to find time to talk about it would tell you that there never were more insistent challenges to constructive thinking than are confronting the South at the present time. Opportunity is written over the whole Southwest: opportunity commercial, opportunity political, opportunity educational, but educational opportunity is written larger than all the rest. We have problems to face, serious ones, that have been perplexing the South for a generation: but even to the most superficial observer it is daily becoming more and more apparent that any solution of these peculiar problems of the South calls for solutions of Southern educational problems in terms of educational opportunities for all the people. Furthermore, the agricultural and industrial transformation now in process of development offers manifold additional arguments to Southern men to prepare their sons for the possession of this land of plenty and progress. Though for nearly a generation the ambitious young Southerner may have seen larger possibilities

ahead of him farther from home, to-day he finds conditions completely changed. Go South, young man! is the slogan in one section. Stay South, young man! is the answering call of opportunity in the other.

In the South and in the West, of the South and of the West, you find yourselves in an environment whose clear skies make men blandly or keenly observant of their powers, whose mild climate keeps men constantly human and neighborly and friendly in ways of living whose democracy recognizes no inequalities; in an environment which will have its way with us unless we have our way with it; an environment bristling with opportunities for creative and constructive effort. You find yourselves in a State which can know no provincialism, because it has lived under seven flags. You find yourselves in a section of that State which lives under a categorical imperative of progress, for we of the plains are drawn by irresistible lure of the prairie, impelled to advance by beckoning mirage quite as wonderful as mountain prospect. You find yourselves among men who live their lives in the open, under a making sun that does not rise but jumps from the horizon full-orbed in his noonday splendor.

And how you do get into your blood and bone the wine and spirit of this country! Speedily you absorb its patriotism and pride, and as speedily come to feel the fearlessness and freedom, the frankness and the faith, that characterize the life of this Texan empire. For this reason it is that in portraying its virtues modesty is not a sin which doth so easily beset us. Houston—heavenly Houston, as it has been happily named by a distinguished local editor of more than local fame—you will find in some ways a bit too close to New York, perhaps, but here you will also find many a heartening reminder of the memories and traditions of the South, and all the moving inspiration in the promise and adventure

of the West. Here, in a cosmopolitan place, in a community shaking itself from the slow step of a country village to the self-conscious stature of a metropolitan town, completing a channel to the deep blue sea, growing a thousand acres of skyscrapers, building schools and factories and churches and homes, you will learn to talk about lumber and cotton and railroads and oil, but you will also find every ear turned ready to listen to you if you really have anything to say about literature or science or art. Of cities there are genera and species and types whose science is still to be written: cities of arms, cities of kings, cities of government, cities of commerce and industry, cities of pleasure and leisure, beautiful cities of art, holy cities of cathedrals and convents, university cities of letters and science. Houston at present may fail of qualifying for admission to certain of these classes, but there is great reason to rejoice in the commercial prosperity of the city and in the growing development of the community; for just as certainly as trade follows the flag, just so certainly does the patron of learning follow in the wake of the empire-builder. For builders of cities, great merchants and captains of industry, by the character of their work and the extent of their interests, are rendered alert, open-minded, hospitable to large ideas, accustomed to and tolerant of the widest divergencies of view. Thus it has come to be that great trading centers have often been conspicuous centers of vigorous intellectual life: Athens, Florence, Venice, and Amsterdam were cities great in commerce; but, inspired by the love of truth and beauty, they stimulated and sustained the finest aspirations of poets, scholars, and artists within their walls. It requires no prophet's eye to reach a similar vision for our own city. I have felt the spirit of greatness brooding over the city. I have heard her step at midnight, I have seen her face at dawn. I have lived under

the spell of the building of the city, and under the spell of the building of the city I have come to believe in the larger life ahead of us, in the house not made with hands which we begin this day to build. However, in the exultation of the moment in which we witness the dedication of the new university, we must not forget that the organization which William Marsh Rice incorporated has already rendered the city and State of his adoption considerable service. I need hardly remind you that during recent years the Rice Institute has contributed in a substantial manner to the upbuilding of Greater Houston. On a conservative basis—always on a conservative basis—certain of the foundation's funds have been invested in various enterprises which have sustained in no small measure the steady and continuous advance of the city in industrial and commercial prosperity.

The epoch whose beginning we observe to-day with these formal exercises marks the period in which even more powerfully that same organization is to support the intellectual and spiritual welfare of the community; and, finally, to touch again upon the material side of progress, the very machinery by which the stone age of the new university is about to be transformed into its spiritual age will distribute the income of the foundation through the several channels of Houston's business, philanthropic, social, and religious life; and thus we contemplate with some degree of satisfaction the slow but sure evolution of a threefold influence on the material, the intellectual, and the spiritual aspects of the life of the city.

III

THE FOUNDATION: ITS HISTORY

IT is now rather more than twenty years since several public-spirited citizens of the community asked Mr. Rice to bear the expense of building a new public high school for the city of Houston. This direct gift to the city's welfare Mr. Rice was unwilling to make, but a few months later, taking into his confidence a half-dozen friends, he made known to them his desire to found a much larger educational enterprise for the permanent benefit of the city and State of his adoption. These gentlemen were organized into a Board of Trustees for the new foundation, which was incorporated in 1891 under a broad charter granting the trustees large freedom in the future organization of a non-political and non-sectarian institution to be dedicated to the advancement of letters, science, and art. As a nucleus for an endowment fund, Mr. Rice at this time made over an interest-bearing note of two hundred thousand dollars to the original Board of Trustees, consisting of himself, the late Messrs. F. A. Rice and A. S. Richardson, and Messrs. James Addison Baker, James Everett McAshan, Emmanuel Raphael,[1] and Cesar Maurice Lombardi. Under the terms of the charter, the board is a self-perpetuating body of seven members elected for life: vacancies since its organization have been filled by the election of Messrs. William Marsh Rice, Jr., Benjamin Botts Rice, and Edgar Odell Lovett.

It was the unalterable will of the founder that the development of the work which he had conceived should progress

[1] In succession to the late Mr. Raphael, whose lamented death has occurred since the reading of this address, Mr. John Thaddeus Scott of Houston has been elected to membership on the Board of Trustees of the Institute.

no further during his lifetime. However, in the remaining days of his life he increased the endowment fund from time to time by transferring to the trustees the titles to certain of his properties, and in the end made the new foundation his residuary legatee. Upon the termination of the long years of litigation which followed Mr. Rice's death in 1900, the Board of Trustees found the Institute in possession of an estate whose present value is conservatively estimated at approximately ten million dollars, divided by the provisions of the founder's will into almost equal parts, available for equipment and endowment respectively. It may be remarked in passing that it is the determined policy of the trustees to build and maintain the institution out of the income, thus preserving intact the principal not only of the endowment fund but also that of the equipment fund. While proceeding to convert the non-productive properties of the estate into income-bearing investments, the trustees called a professor in Princeton University to assist them in developing the founder's far-reaching plans. Before taking up his residence in Houston, the future president visited the leading educational and scientific establishments of the world, returning in the summer of 1909 from a year's journey of study that extended from England to Japan. About this time negotiations were completed by which the Institute secured a campus of three hundred acres situated on the extension of Houston's main thoroughfare, three miles from the center of the city—a tract of ground universally regarded as the most appropriate within the vicinity of the city.

Another early decision of the trustees of the Institute was the determination that the new institution should be housed in noble architecture worthy of the founder's high aims; and upon this idea they entered with no lower ambition than to establish on the campus of the Institute a group of buildings

conspicuous alike for their beauty and for their utility, which should stand not only as a worthy monument to the founder's philanthropy, but also as a distinct contribution to the architecture of our country. With this end in view they determined to commit to Messrs. Cram, Goodhue, and Ferguson, of Boston and New York, the task of designing a general architectural plan to embody in the course of future years the realization of the educational programme which had been adopted for the Institute. Such a general plan, the work of Mr. Ralph Adams Cram, L.H.D., exhibiting in itself many attractive elements of the architecture of Italy, France, and Spain, was accepted by the board in the spring of 1910. Immediately thereafter plans and specifications for an administration building were prepared, and in the following July the contract for its construction was awarded; three months later the erection of a mechanical laboratory and power-house was begun, and by the next autumn the construction of two wings of the first residential hall for men was well under way. In the preparation of preliminary plans for these building operations the Institute enjoyed the cooperation of an advisory committee consisting of Professor Ames, director of the physical laboratory of Johns Hopkins University; Professor Conklin, director of the biological laboratory of Princeton University; Professor Richards, chairman of the department of chemistry, Harvard University; and Professor Stratton, director of the National Bureau of Standards. Among the additional buildings for which tentative studies have already been made are special laboratories for instruction and investigation in physics,[1] chemistry, and biology.

[1] Since this address was read the construction of the physics laboratories has been begun from plans prepared by Messrs. Cram and Ferguson under the direction of Mr. Harold Albert Wilson, D.Sc., F.R.S., resident professor of physics in the Institute. By the beginning of the next academic year (1914–15) these laboratories will be ready for occupancy, as will also the third wing of the first residential hall for men.

IV

THE UNIVERSITY: ITS STUDIES AND STANDARDS

THAT we have been making large plans is already a commonplace of our thinking and talking. In the proposed solutions of some of the problems confronting them the trustees have been moved by several considerations, which may appropriately be recapitulated at this time. In the first place, the financial resources of the institution, however handsome, are limited; for this reason it was determined to build and maintain the Institute out of the income, keeping the principal of all funds intact. In the second place, the new institution is located in a new and rapidly developing country. In the third place, the very problems pressing for resolution in the development of the environment seemed to call for a school of science, pure and applied, of the highest grade, looking, in its educational programme, quite as much to investigation as to instruction.

Accordingly, and in the spirit of the founder's dedication of the Institute, it was proposed that the new institution should enter upon a university programme, beginning at the science end. As regards the letters end of the threefold dedication, it was proposed to characterize the institution as one both of liberal and of technical learning, and to realize the larger characterization as rapidly as circumstances might permit. With respect to the art end, it was proposed to take architecture seriously in the preparation of all of its plans, and to see to it that the physical setting of the Institute be one of great beauty as well as of more immediate utility. This in a nutshell is the programme on which we have

thought with great deliberation and wrought with even greater care. Its chronology to date consists of one year of preparatory study from England to Japan, one year in the making of preliminary plans, and two years in work of actual construction and organization.

The new institution thus aspires to university standing of the highest grade, and would achieve its earliest claims to this distinction in those regions of inquiry and investigation where the methods of modern science are more directly applicable. For the present it is proposed to assign no upper limit to its educational endeavor, and to place the lower limit no lower than the standard entrance requirements of the more conservative universities of the country. Moreover, all courses of instruction and investigation, graduate and undergraduate, will be open both to young men and to young women, and for the present, without tuition and without fees. These courses will be offered by a staff, initially organized for university and college work, ultimately to consist of three grand divisions, science, humanity, technology, each of which will break up into as many or more separate faculties. For these faculties the best available instructors and investigators are being sought wherever they may be found, in the hope of assembling a group of unusually able scientists and scholars through whose productive work the Institute should speedily take a place of considerable importance among established institutions. Friends of education in America would insist that the term "Institute" is too narrow in its connotation, friends of science in Europe would contend that it is too broad. However, in its dedication to the advancement of letters, science, and art, the educational programme of liberal and technical learning now being developed may justify the designation "Institute" as representing the functions of a teaching university of learning, and, at

least in some of its departments, those of the more recent research institutions founded in this country and abroad.

The planning of universities is no new problem. The list of modern solutions under state initiative is a long one from the national universities of Japan at Tokyo and Kyoto down to the reconstruction of the University of Paris and the revival of the French provincial universities; the reorganization of the University of London and the founding of the newer English municipal universities at Durham, Manchester, Liverpool, Birmingham, Leeds, Sheffield, and Bristol; the newest members of the German system in the universities of Frankfort, Dresden, and Hamburg; and the conspicuous development of state institutions in our own country—to name but a few, in the new California under Wheeler, the new Illinois under Draper and James, the new Texas under Houston and Mezes, the new Virginia under Alderman, and the new Wisconsin under Van Hise. And at this very moment there are building two new universities in Hungary, three in Canada, and two in Japan, while plans are being formulated for new institutions in China, Australia, and South Africa. Within the memory of all of us there have arisen on the benefactions of American philanthropists the Johns Hopkins University under Gilman and Remsen, Cornell University under White and Adams and Schurman, the University of Chicago under Harper and Judson, Leland Stanford under Jordan, and Clark under Hall; while the same period of university building has witnessed equally striking evolutions in the older American private foundations, notably the new Harvard under Eliot and Lowell, the new Yale under Porter and Dwight and Hadley, the new Princeton under McCosh and Patton and Wilson and Hibben, the new Columbia under Low and Butler, and the new Pennsylvania under Harrison and Smith.

It has been remarked that an inventory of present-day universities would reveal thirteenth-century universities, fifteenth-century universities, nineteenth-century universities, and twentieth-century universities in formidable array and considerable confusion. There are universities that swear by Plato, others by Euclid, and others by Adam Smith. Some uphold the Thirty-nine Articles, while others worship radium and helium. From glorified engineering shops to scholastic sanctuaries, they offer the widest possible choice of type.

Nevertheless, there has been evolving a composite conception of the university in some such characterization of its functions as follows:

First, from the persistent past, in which there are no dead, to embody within its walls the learning of the world in living exponents of scholarship, who shall maintain, in letters, science, and art, standards of truth and beauty, and canons of criticism and taste.

Second, for the living present and its persistence in the future, to enlarge the boundaries of human learning and to give powerful aid to the advancement of knowledge, as such, by developing creative capacity in those disciplines through which men seek for truth and strive after beauty.

Third, on call of State or Church or University, to convey to its community and commonwealth, in popular quite as much as in permanent form, the products of its own and other men's thinking on current problems of science and society, of government and public order, of knowledge and conduct.

Fourth, in support of all institutes of civilization and all instruments of progress, to contribute to the welfare of humankind in freedom, prosperity, and health, by sending forth constant streams of liberally educated men and women

to be leaders of public opinion in the service of the people, constant streams of technically trained practitioners for all the brain-working professions of our time, not alone law, medicine, and theology, but also every department of service and learning, from engineering, architecture, commerce, and agriculture, to teaching, banking, journalism, and public administration.

As thus conceived, the university is a great storehouse of learning, a great bureau of standards, a great workshop of knowledge, a great laboratory for the training of men of thought and men of action. Under this conception of its functions the university has to do with the preservation of knowledge, with the discovery and distribution of knowledge, with the applications of knowledge, and with the making of knowledge-makers. Singling out one line of its activities, the business of a university is to teach science, to create science, to apply science, to make scientists. To be even more specific, its objects in the department of chemistry are to teach chemistry, to create chemistry, to apply chemistry in all the arts of industry and commerce, and to make more creative chemists. This conception of the manifold function of a university in scholarship, in science, in social service, and in civilization corresponds point by point to the fourfold function of the career of a scholar or scientist: in scholarship, a conservator of knowledge; in science, a creator of knowledge; in citizenship, a contributor to public opinion; in service, a controller of the destiny of the cherished institutions of civilization.

However, even to those who recognize in patriotism, education, and religion supreme enterprises of the human spirit, education itself is proverbially a dull subject whose technical details are sometimes dry as dust. For instance, I am by no means convinced that a discussion of the metaphysics of the

optative mood in Greek would be especially edifying on this occasion. Then, too, mathematical studies are poems of a variety better appreciated when read in private than when declaimed in public. Nor are you likely moved at this time by any overpowering desire for relief from the perplexity of that dear old lady who said she could readily make out how astronomers determined the distances and dimensions, masses and motions, constitution and careers of the heavenly bodies, but for the life of her she never could understand how they found out their beautiful names.

But studies and standards, students and staff are elements of a university programme quite as important as are a machine-shop, a file of journals, a lively imagination, and a printing-press, its other constituent parts. If a university should take all knowledge for its province, it becomes necessary to undertake a classification of knowledge, a problem never yet done with satisfaction to any one except perhaps the last man attempting it. Nor is the problem rendered inordinately simple when restricted to a programme in science, for, to say nothing of more recent modifications upheaving in character, the scientific thought of the nineteenth century has been made by Dr. J. Theodore Merz to align itself in a stately march of no fewer than ten views of nature: the astronomical, the atomic, the kinetic, the physical, the morphological, the genetic, the vitalistic, the psychophysical, the statistical, and the mathematical views.

Yet all would agree, I think, that in mathematics, physics, chemistry, biology, and psychology we have a logical series carefully co-ordinated in subject-matter and sequence, furnishing the theoretic foundations for the applied sciences of engineering, economics, eugenics, and education. Furthermore, there would also be agreement in the opinion that this co-ordinated series should be flanked both right and left by

history and its interpretation, as a great laboratory in which to test all plans for political or social reform; by philosophy, as a clearing-house for all theories and methods of knowledge; by letters, as the record in "thoughts that breathe and words that burn" of all human striving after sweetness and light; and by art, the creative imagination's flowering product in the ennobling and enriching of the content of life. Our studies are thus to be centered in the fundamental branches of pure science with a view to solutions of problems of applied science in engineering, whose chief business is the development of the material resources of the world; in economics, whose cardinal problem is that of the distribution of the wealth thus produced; in eugenics as the newest of the sciences, but really in idea no younger than Plato, which by taking thought would add cubits to the stature of the race; and finally in the latest of the experimental sciences, namely, education itself, in whose philosophical, psychological, and physiological foundations are now being sought the surest means of training the intellects and stimulating the imaginations of men.

V

THE UNIVERSITY: ITS SAINTS AND SEERS

AS thus projected on a background of philosophy, history, letters, and art, the programme of this university of science stands forth in the effigies and inscriptions which have been cut in the walls of this the first house of the home of its spirit.

On the caps of the cloister's granite columns appear the heads of sixteen founders, leaders, and pioneers in

Religion	St. Paul
History	Thucydides
Philosophy . . .	Immanuel Kant
Art	Michelangelo
Jurisprudence . . .	Thomas Jefferson
Medicine	Pasteur
Engineering . . .	De Lesseps
Commerce . . .	Christopher Columbus
Mathematics . . .	Sophus Lie
Physics	Kelvin
Chemistry . . .	Mendeleeff
Biology	Charles Darwin
Electric Oscillations .	Heinrich Hertz
Aerodynamics . .	Samuel Langley
Radioactivity . . .	Pierre Curie
Eugenics	Richard Galton

The obvious guiding call in this consistory of canonization was to pass from the ancient enterprises of humane learning to the modern endeavors of scientific exploration. An accident of considerable interest is the circumstance that in the first group are a Greek, a Hebrew, a Latin, and a Teuton, while in the last are representatives of America, England, France, and Germany.

On the exterior wall of the Faculty Chamber the threefold dedication is emblazoned in marble tablets to letters, science, and art. The Tablet to Letters bears the head of Homer, below which is inscribed Mackail's translation of Pindar's tribute to style:

"The thing that one says well goes forth with a voice unto everlasting."

The Tablet to Science bears the profile of Isaac Newton together with Job's anticipation of the method of scientific inquiry in his

"Speak to the earth and it shall teach thee!"

The Tablet to Art bears the head of Leonardo da Vinci, under which is inscribed:

"The chief function of art is to make gentle the life of the world."

Adapted, after some modifications, from certain of Abbey's mural decorations in the State Capitol of Pennsylvania, modeled by C. Percival Dietsch, and executed by Oswald Lassig, are the two life-size draped figures adjoining the court side of the arch of the sally-port on the left and right

respectively: one, symbolic of Science, screening her gaze under the cautious and somewhat uncertain lead of reason, proceeds under Aristotle's dictum:

"If we properly observe celestial phenomena we may demonstrate the laws which regulate them";

the other, symbolic of Art, in an inspirational attitude, with neither fear in her face nor faltering in her step, emerges from the chiseled intuition of Plotinus that

"Love, beauty, joy, and worship are forever building, unbuilding, and rebuilding in each man's soul."

Again, under the shield of the State of Texas and the shield of the Rice Institute and the Flowering Magnolia of the City of Houston, the chief stone of this building bears what is perhaps the best expression of the Spirit of Science in any tongue: a Greek inscription in Byzantine lettering, from the *Præparatio Evangelica* of Eusebius Pamphili, the first historian of the Church, which, in the translation of the late Samuel H. Butcher, reads:

" 'Rather,' said Democritus, 'would I discover the cause of one fact than become King of the Persians,' "

—a declaration made at a time when to be king of the Persians was to rule the world. In thus preserving in the twentieth century of our era this utterance of exultant enthusiasm for knowledge for its own sake, from a representative philosopher of that people who originated the highest standards in letters and in art, the trustees of the Institute have sought

to express that disinterested devotion both to science and to humanism which the founder desired when he dedicated the new institution to the advancement of literature, science, and art.

From inspiration out of the past we pass to the inspiration of the living, and in particular to the heartening hail of those savants who have come or stretched their hands across the seas to us on this occasion. Under sunny skies whose clear air makes clear minds blandly or keenly observant of the world, with winds fair, on the anniversary of Columbus's arrival, we too are setting out on a voyage of discovery in three small craft whose lines and keels and turrets you have had opportunity to examine and admire. We pledge your standards at the masthead and your spirit in the crew, but until we find our treasure island, where faith and promise brighten into performance and achievement, we have none but empty honors to offer you. Rather do we ask you to honor us still further by allowing us to place in the stateroom of the flagship the following tablets in commemoration of your visit to the fleet:

Professor Rafael Altamira y Crevea, of Madrid, Spain: late Professor of the History of Spanish Law in the University of Oviedo; Director of Elementary Education in the Spanish Ministry of Public Instruction; a scholar of recognized authority in the history of jurisprudence and politics, and a statesman whose public service has extended with increasing usefulness beyond the borders of his own country to the educational institutions of the Latin-American nations.

Professor Emile Borel, of Paris, France: Director of Scientific Studies at the Ecole Normale Supérieure; Editor-in-chief of *La Revue du Mois;* Professor of the Theory of

Functions at the University of Paris; successful in the discharge of exacting duties as administrator, educator, and editor, his studies in mathematical analysis worthily maintain the standards of scientific work established by the historic line of French analysts extending from Lagrange and Laplace to Hermite and Poincaré.

Senator Benedetto Croce, of Naples, Italy: Life Senator of the Italian Kingdom; Member of several Royal Commissions; Editor of *La Critica;* an original and profound thinker, both constructive and critical, whose philosophy of the spirit, and in particular its theory of æsthetics, has compelled world-wide attention on the part of artists, philosophers, and men of letters.

Professor Hugo de Vries, of Amsterdam, Holland: Director of the Hortus Botanicus and Professor of the Anatomy and Physiology of Plants in the University of Amsterdam; a careful observer and patient investigator of the phenomena of growth and change in living things, whose studies and experiments of a quarter of a century have resulted in capital contributions to the theories of heredity and the origin of species.

Professor Sir Henry Jones, of Glasgow, Scotland: Fellow of the British Academy; Professor of Moral Philosophy in the University of Glasgow; Hibbert Lecturer on Metaphysics at Manchester College, Oxford; an erudite editor and expositor of great movements of reflective thought in poetry and philosophy and religion, and himself a genial human philosopher who has elaborated a working faith for the social reformer and professed the doctrines of idealism as a practical creed.

Privy Councilor Baron Dairoku Kikuchi, of Tokyo, Japan: late Japanese Minister of Education; formerly President of the University of Tokyo, and later of the University of Kyoto; recently Lecturer on Japanese Education at the University of London; a publicist of distinction and a close student of affairs, one of the pioneers in the introduction of Western learning into Japan, who has rendered his native land patriotic service in the organization and administration of its schools and universities.

Professor John William Mackail, of London, England: former Fellow of Balliol College and later Professor of Poetry in Oxford University; a critic who would interpret art as art interprets life, favorably known by his many published lectures on Latin literature and Greek poetry, and himself a poet whose English pure and undefiled is scarcely surpassed in our time.

Privy Councilor Professor Wilhelm Ostwald, of Gross-Bothen, Germany: late Professor of Chemistry in the University of Leipsic; Nobel Laureate in Chemistry, 1909; a versatile man of science whose interests and activities range from art through letters into metaphysics, he is justly celebrated as one of the founders of physical chemistry and equally well known as the chief propagandist of a new natural philosophy based on the theories of energetics.

The late Professor Henri Poincaré, of Paris, France: Member of the French Academy; Commander of the Legion of Honor; Professor of Mathematics and Astronomy at the University of Paris; distinguished for discoveries of far-reaching significance in pure mathematics, celestial mechanics, and mathematical physics, a varied intellectual activ-

ity of extraordinary fertility has secured for him a place of eminence in letters, in science, and in philosophy.

Professor Sir William Ramsay, K.C.B., of London, England: late Professor of Chemistry at University College, London; Nobel Laureate in Chemistry, 1904; President of the Seventh International Congress of Applied Chemistry; a facile experimenter of boldness and ingenuity, who has devised new theories and revived outworn ones in a series of remarkable achievements which of themselves constitute an epoch in the history of the chemical elements and a permanent chapter in the annals of science.

Professor Carl Størmer, of Christiania, Norway: Member of the Norwegian Academy of Sciences; Associate Editor of the *Acta Mathematica;* Professor of Pure Mathematics in the University of Christiania; professorial successor of the illustrious Norse geometer, Marius Sophus Lie, and himself a master of the methods of reckoning who has drawn from the equations of mechanics a new theory of terrestrial magnetism revealing new explanations of the lights of the northern skies and kindred manifestations in the solar system.

Professor Vito Volterra, of Rome, Italy: Life Senator of the Italian Kingdom; Dean of the Faculty of Science and Professor of Mathematical Physics and Celestial Mechanics in the University of Rome; recently Lecturer in the Universities of Paris and Stockholm; an analyst of rare skill whose theories have found manifold applications both in pure and in applied science, he has served his country even more directly as an able organizer of educational and scientific undertakings national in scope and international in influence.

VI

THE UNIVERSITY: ITS STUDENTS AND STAFF

FROM the hands of these illustrious citizens of Amsterdam, Glasgow, Leipsic, London, Madrid, Naples, Oxford, Paris, Rome, and Tokyo, the torch of civilization's great commission to think and to teach and to learn is this day passed on to the sons and daughters of the South and the scholars and scientists trained at the universities of Cambridge, Chicago, Harvard, Heidelberg, Leipsic, Michigan, Oxford, Pennsylvania, Yale, Virginia, Wisconsin,[1] who constitute the charter membership of the new institution's academic guild, a company of students and fellows, lecturers and instructors, preceptors and professors, who in a common society would seek to realize a composite conception of the student-universities and the master-universities of earlier times; a voluntary association whose collective will for the present is to be executed by one of their number, who is to

[1] Since this address was written the staff of the new institution has grown to some thirty members who bring to its problems training, experience, or honors from the following universities and colleges: Adelphi, Auburn, Balliol (Oxford), Berlin, Bethany (West Virginia), Birmingham, Bonn, Cambridge, Centre, Chicago, Christiania, Clark, Columbia, Cornell, Davidson, Drake, Emmanuel (Cambridge), Georgia, Göttingen, Harvard, Heidelberg, Illinois, Johns Hopkins, King's (London), Leeds, Lehigh, Leipsic, Liverpool, London, McGill, Michigan, Minnesota, Missouri, Munich, Northwestern, Oberlin, Oxford, Paris, Pennsylvania, Pittsburg, Princeton, Robert, Rome, Southwestern, Stanford, Trinity (Cambridge), Tulane, Union, Vermont, Virginia, Washington (College), Washington (University of), Wesleyan, Williams, Wisconsin, Wooster, Yale; and the student members of an academic community of about three hundred souls come from some seventy-five towns in Texas and fifteen States of the Union, among them holders of degrees from Austin, Georgetown, Missouri, Phillips, Robert, Union, and Vanderbilt, and former students of Austin, Baylor, Daniel Baker, Georgia School of Technology, Howard Payne, Illinois, Lehigh, Marion Institute, North Texas Normal, Oklahoma (Agricultural and Mechanical), Randolph Macon, St. Mary's, Sam Houston Normal, Simmons (Texas), Smith, Sophie Newcomb, Southwestern, Sweet Briar, Texas (Agricultural and Mechanical), Texas (University of), Trinity (Texas), United States Military Academy.

play the rôle of middleman between the public and the university, the trustees and the staff, the staff and the students, the students and their parents and guardians; a society of scholars which from the first aspires to be "a partnership in all science, a partnership in all art, a partnership in every virtue and in all perfection"; and "as the ends of such a partnership cannot be obtained in many generations," to appropriate still further Burke's conception of the state, "it becomes a partnership between those who are living, those who are dead, and those who are to be born."

Democracy of science and republic of letters, nowhere mere empty phrases, meet in this partnership an unusual opportunity for translation into living actualities. Except for the organization indispensable to the efficient discharge of business, subject only to limitations of character and intellect, here are leisure and work and liberty, freedom in initiative, freedom in invention, the freedom that alone invites inspiration to thought and action. As at the University of Virginia from the earliest days, and more lately at the University of Chicago, distinctions of academic rank and title will appear in official calendars but find no place in classroom or on the campus. For purposes of organization and administration each member of the university will naturally fall into one or more of three grand divisions: Science, Humanity, Technology. As has already been intimated, each of these divisions will eventually consist of several faculties: under Science we should have mathematics, physics, chemistry, biology, psychology, and so on, together with their applications in the fields of engineering, economics, education, and so forth; under Humanity would appear history, philosophy, letters, politics, and so on to art and religion; while Technology would embrace science, humanity, and technology as professions of teaching or research, the

older learned professions of law, medicine, theology, and the newer ones from engineering, architecture, and agriculture on down to the more recent acquisitions of commerce, banking, and public administration.

The first larger divisions of the Staff of the new university to assume form will be a faculty of science and a faculty of letters. In the discharge of their functions these bodies will be aided by administrative committees constituted of their own members. To the duties of the officers of certain of these committees deans will succeed when the growth of the institution shall have called for more elaborate and more highly differentiated machinery of organization and administration. Administrative work, of increasing complexity in any modern university, is likely to make frequent calls on the time and judgment of its ablest and best trained members in the first days of a new one, but it is hoped to reduce the burden of these demands considerably by consistent and sharp differentiation between the constructive and critical, and the clerical. To meet the direct duties of administration in schools and departments, laboratories and museums, chairmen will be appointed annually and without regard to seniority. The Staff will assemble, and at regular intervals, in at least three different series of meetings: scientific, social, and business. Through the first of these the work of its members in the capacity of creator, critic, or censor will be assessed in its relations to productive scholarship; by the second, the university will be kept in intimate touch with the life of its community, and many a plan may trace its start to a bowl of punch or the pouring of tea; and finally, through the third of these series of meetings the Staff will consider, subject to the approval of the trustees, the conduct of the academic life of the university in respect of scholarship, research, teaching, and public service.

In America the spirit of scientific investigation has, certainly until recently, found its best expression in the college and the university, and among the men of science associated with these foundations. To be sure, research institutions, as for example the Scientific Bureaus of the United States Government, the Carnegie Institution of Washington, the Rockefeller Institute in New York, and, earliest of all, the Smithsonian Institution in Washington, independent of universities, have abundantly justified their existence among us; but no university can live without the vitalizing reaction of original investigation. Even in the Rice Institute's days of hewing of wood and mixing of mortar, work of investigation is not to be allowed to suffer from any inconvenience due to inadequate provision of library and laboratory apparatus. The first investigators may feel their isolation and the absence of atmosphere, but in this day of rapid transit, speedy dissemination of intelligence, and manifold multiplicity of periodical scientific publications, isolation offers no excuse for inactivity, for one cannot spend half an hour in the perusal of a first-class scientific periodical without thinking of at least half a year's things to do.

To the privileges of research and the duties of administration must be added the pleasures of teaching and public lecturing, and if the last phase of this cycle of action is to be efficient the schedules of daily and weekly performances should not be too heavy. Moreover, the time-tables of lecture and laboratory arrangements in each subject of instruction or investigation will be so framed that the first-year students shall be brought directly under the tutelage of the senior members of the university: here again we are appropriating an idea of Thomas Jefferson's for the University of Virginia. Furthermore, this very work of teaching and public lecturing will itself be inspired by the temper of scientific

investigation; for, as it seems to me, the scientific movement of the nineteenth century has no more striking lesson for the twentieth than that an inquiring mind is the safest guide for an inquiring mind: that the best man to lead the learner from the unknown to the known is the man who is continually leading himself from the unknown to the known, not only in point of encyclopedic and specialized knowledge, but also in point of new knowledge contributed by himself to the store of learning. Was Burke not right when he said that "the method of teaching which approached most nearly to the method of investigation is incomparably the best, since, not content with serving up a few barren and lifeless truths, it leads to the stock out of which they grew; it tends to set the learner on the track of invention and to direct him into those paths in which the author has made his own discoveries"? And Burke said this half a century before the scientific renaissance. Nor was Burke an impractical dreamer, for, in his speech on the petition of the Unitarians, he also said: "No rational man ever did govern himself by abstractions and universals. . . . A statesman differs from a professor in a university. The latter has only the general view of society. . . . A statesman, never losing sight of principles, is to be guided by circumstances; and, judging contrary to the exigencies of the moment, he may ruin his country forever."

Finally, to the energy and invention of the planner, to the enthusiasm and initiative of the producer, to the erudition and imagination of the professor, must be added the energy and enthusiasm and erudition of the preceptor, whose power of summary statement in exposition, whose infinite capacity for details in explanation, whose persistent example and occasional exhortation in manners and morals, must conspire with strength of personality to win and guide the student's

interest in his reading and writing quite as much as in his thinking and in the meeting of his formal obligations to the university's standards and scheme of studies. This order of ideas goes back to a modification of the Oxford and Cambridge tutorial system which President Wilson introduced at Princeton University several years ago. And the finest thing about the introduction of President Wilson's preceptorial system at Princeton University was not the bringing of forty preceptors to Princeton at one blow, but rather the calling of every professor of the university to personal participation in the plan as preceptor. The success of that system at Princeton is to be attributed to this professorial participation no less than to the larger part taken in the execution of the plan by the specially appointed junior members of the staff.

Thus it appears that a professor's work is never done. Probably no expenditure of his time meets with smaller return than that employed on editorial duties. Moreover, in a time when the world is flooded with printing one should hesitate to increase the number of printed pages. Nevertheless, in order to facilitate the prompt publication and distribution of the products of its library, laboratory, and lecture activities, the new university proposes to maintain a few periodical publications of its own. Perhaps the most serious of these will be the *Annals of Letters, Science, and Art,* to appear ultimately in several series, carrying the contributions of its own and other scholars to knowledge. Simultaneously with these quarterly quartos there will appear *The Rice Institute Pamphlets,* in octavo form, at least four times a year, containing occasional addresses, courses of lectures, and smaller papers of current and timely interest. And finally, at least for the present, the *Circulars of Information* concerning the Rice Institute, in the numbers of which will be published the annual calendar, the programmes of study,

and other announcements of the undergraduate and graduate life of the institution.

'T is a bold man who would take upon himself the gift of prophecy, but from the birth of the science of the stars to the physics of the ether and the ion it has been the province of the professor to prophesy; sometimes, as the prophet of old, to "stand like a wall of bronze, and an iron pillar, against the whole land, against the kings of Judah and the princes thereof"; but always striving, in the spirit of a modern philosopher whose noble words might be turned into a command and written over the door of every library, laboratory, and lecture-hall as a motto for all seekers after truth, to "cherish as a vital principle an unbounded spirit of enquiry and ardency of expectation, unfetter the mind from prejudices of every kind, leave it open and free to every impression of higher nature which it is susceptible of receiving—guarding only against self-deception by a habit of strict investigation—encourage rather than suppress everything that can offer the prospect of a hope beyond the present obscure and unsatisfactory state. The character of the true philosopher is to hope all things not impossible and to believe all things not unreasonable. . . . Humility of pretension no less than confidence of hope is what best becomes his character." It is the business of the professor quite as much as it is the business of the successful promoter to get results out of the future by anticipating them through his knowledge of the past and his understanding of the present. On such an occasion as this it is hard not to prophesy. This academic festival provides the first alignment of the Rice Institute with other institutions. It is the placing of a new university on the map of the earlier universities. The new institution comes as a rival to none, as a competitor of none, but as a child hoping to grow in favor, to gain the confidence and to win the re-

spect of older foundations. It is the advent of a man-child that we have witnessed, and some of us believe we have discovered in its form the features and bones of a giant. And I like to think that within ten or twenty years the staff and students of whom I am now speaking will have grown to be a residential community of at least a thousand souls—or, say a staff of a hundred members and a society of students a thousand strong. And the year that number, one thousand, has been reached—a graduate group of two hundred and an undergraduate group of eight hundred—we propose to say that in the year following only the best thousand among the applicants for admission, whether old or new, shall be received, and to persevere in this process of selection year by year for another score of years. This determination of ours has been accorded hearty support by many of our guests on this occasion; for if they have urged one thing above another upon us, that one thing has been to keep the standards up and the numbers down. It is through such standards in scholarship and service severely maintained, and by a process of selection through these standards of culture and character, that the exceptional man is likely to be discovered. And, after all, is not this last discovery one of the highest forms of service within our aim?

For the maintenance of these high standards we have promising material with which to begin. These first students who have come to us have come to us on faith; they have left the beaten paths to established institutions; they have left the company of their fellows to come to a new institution; and to this institution they have come unsolicited and unheralded; they have thus shown some independence of judgment, something of initiative, somewhat of the spirit of adventure, and these are the things by which men are judged and singled out from among their fellows at every stage of

the game of life. For these reasons we believe that we make no mistake in banking on these young men and women and the future of the new university at their hands.

And if we hope that this academic community is to be distinguished by high standards in scholarship, we also hope that the student life of the community is to be equally distinguished for its system of self-government. The latter system is already assuming form through the constitution of an honor system for the conduct of examinations, and the institution of student government in the first halls of residence.[1] With these two strong determinants of public opinion, the extension of student control to the entire campus should prove to be a comparatively simple undertaking. In the so-called honor system in examinations there is nothing novel to many American institutions. Two generations ago such a system grew into existence at the University of Virginia, and some years later found a congenial atmosphere at Princeton. Since these beginnings it has grown into the life of many other colleges. On the other hand, in some universities it has been tried without success. In the first days of a new one, however, when all traditions and customs are in the making, it promises well. And because of this same freedom—that is to say, freedom from tradition—the Rice Institute is pre-eminently fortunately situated to undertake the building of halls of residence as an integral part of its programme. As a matter of fact, the residential college idea is a prominent one in the plans of the new institution. At the time these plans were being made the idea was stirring in the air about many of the older universities. It was at Princeton

[1] The Honor Council this year (1914–15) has representatives from three classes, and in another year will have become a permanent institution in the university. In the conduct of examinations during the first two years of the institution's existence, this council has been vigilant in its care. The government of the residential college is in the hands of an elective board of representatives, chosen one each from the ten or a dozen separate houses into which the hall of residence is divided.

that President Wilson proposed to give the idea concrete form in the reorganization of the social life of that ancient seat of learning. The programme there suggested was an adaptation of the English residential college to American undergraduate life. A similar plan had been elaborated by Dean West some years earlier for a future school of graduate studies at Princeton, and the latter plan has come to realization in the Gothic halls and towers of the Princeton Graduate College about to be dedicated. From Oxford and Cambridge the idea goes back to the University of Paris, the mother university of all modern ones, which consisted originally of residential colleges. In the Paris of the present day the type reappears in the Ecole Normale Supérieure, founded by Napoleon, and in the more recent Fondation Thiers. Moreover, in Berlin an original suggestion of Fichte's in his scheme for a university has led lately to proposals for such a development at the university which bears the name of that city; while at the same time in our own country the University of Wisconsin has plans for residential halls already worked out and awaiting funds from the State; Cornell University has undertaken such a plan, the first buildings of which are soon to be constructed; and Harvard has planned for the freshmen of the university a group of such colleges to be ready for early occupancy.

The first of these experiments in college democracy at Rice finds its dedication on the corner-stone of its building, where, under the shield of the Institute, there appears the simple inscription: "To the freedom of sound learning and the fellowship of youth." Here is being realized an old seventeenth-century definition of education—William of Wykeham's "the making of a man."[1] For here in the resi-

[1] This definition of education was made the subject of his inaugural discourse at Princeton University by President Hibben, at whose recent installa-

dential college men live in freedom, checked only by self-mastery and gentle manners, a freedom of the kind that Goethe meant when he said, "He alone attains to life and freedom who daily conquers them anew"; here they grow in wisdom, not alone in the wisdom of books but also in the wisdom of work and service; here they find the incom-

tion there appeared for the first time in an American academic procession an official representative of the Rice Institute.

In many respects the present address is a chronicle of first things—first either in point of time or in point of import.

The first scientific papers by a member of the Rice Institute were presented to the American Mathematical Society and the American Philosophical Society.

The first foreign reference to the new foundation was made by Dr. Henry van Dyke in a public lecture at the Sorbonne in his course on "The Spirit of America" as visiting professor at the University of Paris, in which, speaking of the development of education in our country, he said: "Nor has this process of assimilation been confined to American ideas and models. European methods have been carefully studied and adapted to the needs and conditions of the United States. I happen to know of a new institution of learning which has been recently founded in Texas by a gift of ten millions of dollars. The president-elect is a scientific man who has already studied in France and Germany. . . . But before he touches the building and organization of his new Institute, he is sent to Europe for a year to see the oldest and the newest and the best that has been done there. In fact, the Republic of Learning to-day is the true Cosmopolis. It knows no barriers of nationality. It seeks truth and wisdom everywhere, and wherever it finds them, it claims them for its own."

The first printed scientific papers to be dated from the Rice Institute were published in the "American Journal of Mathematics," the "Cambridge Journal of Pure and Applied Mathematics," the Proceedings of the American Philosophical Society, and "Science." The first address by a member of the Institute was a vice-presidential address before the Baltimore meeting of the American Association for the Advancement of Science, which included some results of a paper presented previously at the Dublin meeting of the British Association for the Advancement of Science. The first literary addresses written at the Rice Institute were a Phi Beta Kappa address on the mind and temper of science, delivered at the University of Virginia in June, 1910, and a commencement address on the spirit of learning, delivered at the University of Texas in June, 1911.

The first scientific paper to go out from the laboratories of the Institute was one by Mr. and Mrs. H. A. Wilson, published in the Proceedings of the Royal Society of London; while the first scientific paper to be published by a student of the Institute was one by Mr. Eric R. Lyon, an undergraduate, which appeared in the "American Physical Review."

The first book to carry "Rice Institute" on its title-page was Mr. J. S. Huxley's Cambridge manual on "The Individual in the Animal Kingdom." The second such book was Mr. A. Ll. Hughes's "Photo-electricity," issued by the Cambridge University Press, and now in process of translation into German in Germany. Books from the pens of Mr. Guérard and of Mr. and Mrs. Tsanoff, though prepared elsewhere, have appeared in print since their authors came to Houston. Furthermore, Mr. Wilson has a new book in the

parable fellowship, warm comradeship, and joyous companionships of college years; here they live in the unconquerable enthusiasm, the fearless courage, the boundless hope of youth. A faithful characterization of the spirit of the hall is found in the following lines from Wordsworth's "Prelude":

Nor was it least
Of many benefits, in later years
Derived from academic institutes
And rules, that they held something up to view
Of a Republic, where all stood thus far
Upon equal ground; that we were brothers all
In honour, as in one community,
Scholars and gentlemen; where, furthermore,
Distinction open lay to all that came,
And wealth and titles were in less esteem
Than talents, worth, and prosperous industry.
Add unto this, subservience from the first
To presences of God's mysterious power
Made manifest in Nature's sovereignty,
And fellowship with venerable books,
To sanction the proud workings of the soul,
And mountain liberty.

In this first residential hall students and staff are already living in a common society a common life under conditions

press, Messrs. Caldwell, Daniell, Evans, and Guérard have books in the making, Messrs. Axson and Dumble have courses of public lectures on literature and science in manuscript awaiting publication in the Pamphlets of the Rice Institute, while Messrs. Daniell, Evans, Graustein, Guérard, Hughes, Huxley, Reinke, and Tsanoff have contributed to literary and scientific periodicals papers which were written at the new university.

Though this recital does not attempt to be exhaustive, no account of the initial scholarly work of the new institution should fail to mention the inaugural lectures and other performances of the formal opening to which reference has already been made. The omission here of details concerning the first Rice Institute university extension lectures will be supplied in a subsequent paragraph of this paper.

the most democratic. They sit at a common table; they lounge in common club-rooms; they frequent the same cloisters; in games they meet again upon the same playing-fields. The quadrangle is self-governed, with no other machinery of government than is necessary to conduct a gentlemen's club. To the quadrangle, as to the college, the only possible passports are intellect and character. In the quadrangle, as on the campus, the business of life is to be regulated by no other code than the common understanding by which gentlefolk determine their conduct of life, constantly under the good taste, the good manners, the enduring patience of gentle minds, among strong men who believe that he lives most who works most, labors longest, worries least. Each hall is to have its own literary and debating society, its own religious association, and its own musical and athletic organizations.[1] A little later in the history of the Institute similar colleges will be provided for the young women. It is hoped that ultimately all students of the Institute will be

[1] From the start the students of the Rice Institute, irrevocably committed to canons of clean sport, have participated, under the direction of Mr. Arbuckle, in all forms of intercollegiate athletic contests. Following the organization of the Rice Institute Athletic Association, the first society of students to be organized at the Rice Institute was the Young Men's Christian Association. This step on the part of the young men was speedily followed by a similar step on the part of the young women in the organization of their branch of the college Young Women's Christian Association. Each of these religious associations has held regular meetings continually since. Both have contributed to the social life and the religious spirit of the Institute. Regular classes in Bible study, meeting weekly throughout the year, are being conducted by Messrs. Johnson and Tsanoff. The college student, above all his kind, is a political animal, and, to a degree far beyond what some people think, a religious being. For this reason it is gratifying to say that the internal religious forces of the new institution have been constantly and consistently growing in strength. The founding of the religious societies was followed by the forming of three literary societies, one by the young women, bearing the name of Elizabeth Baldwin, wife of the founder of the Institute, and two by the young men, known respectively as "The Owl Literary Society" and the "Riceonian Literary and Debating Society." These societies have met weekly from the date of their organization, and have held occasional intersociety meetings in public debate. Though founded by student initiative, the literary and debating societies have called to their assistance in an advisory capacity a committee consisting of Messrs. Arbuckle, Axson, Daniell, Evans, Huxley, Hughes, and Watkin.

housed in such halls of residence. For example, the residential section for men calls for a great quadrangle of quadrangles, whose main axis terminates at one end by a great gymnasium and at the other by a great union club. In the gymnasium all students will receive systematic work in physical education, while the union will offer many opportunities open by competition to members of all colleges, for among these colleges there will arise the liveliest sort of rivalry in scholastic standing, in field sports, in musical, literary, and debating activities. To those students who for one reason or another are obliged to live in the city the union will afford many of the opportunities of the residential hall. By thus providing in the way of dwelling halls units larger than those provided heretofore in American institutions it is hoped to preserve and to maintain the present democratic conditions of life which obtain on the campus of the new university. And to that end, side by side with the building of great laboratories of investigation and halls of instruction is to proceed the building of these collegiate homes for human living. Each of these homes will have its roll of honor and hall of fame, and, even as the older colleges, will point with pride to men of initiative and achievement who were former members of the hall. Though these halls may not go as far as Balliol College went under Jowett's mastership and receive as students only those who are candidates for honors, yet, "scorning delights" and "living laborious days," may they not look forward to a time when their historian may say as does Mr. W. W. Rouse Ball of his college, Trinity, Cambridge—to name another English college represented in the first faculty of Rice: "This particular staircase, which I have taken as a typical one, contains one Fellow's set, five undergraduates' sets, one of which is now used by the porters, and an odd room. The rooms on the ground floor

on the right-hand side on entering the staircase were occupied by Thackeray, and later by the present Astronomer-Royal; those on the opposite side, by Macaulay; the rooms on the first floor next the gate were occupied by Isaac Newton, and later by Lightfoot, afterwards Bishop of Durham, and R. C. Jebb, the Greek scholar; and those on the opposite side by J. G. Frazer, who has done so much to investigate the habits of thought of primitive man. This is an interesting group of men, but in fact there are few rooms in the college which have not been inhabited at some time by those who have made their names famous."

A distinguished mathematician in Germany said very recently that American college spirit is the greatest need of the German university. To this academic audience college spirit is neither novel nor unreal. The boldness in commenting upon it may be pardoned when I remind you that it itself is freedom, courage, comradeship. It is the freedom of sound learning and the fellowship of youth; it is the spirit of solidarity, the spirit of co-operation, the collective spirit of corporate unity. It appears upon the rostrum, at the desk, and in the field, on the gridiron and the diamond and the track. Always it is the spirit of romance, occasionally of revelry, sometimes of reformation, and frequently, in its most serious and sober moments, bent on nothing more sober or serious than recreation. In manners it demands simplicity and sincerity; in morals, honesty and integrity. It laughs at pedantry, howls at the pompous, rebels at cant, exults in candor. In judgment merciless, if not always unerring; in action immediate, if sometimes unreflecting; of robust adventure "that buildeth in the cedars' tops and dallies with the wind and scorns the sun"; of virile sport that "greets the unknown with a cheer and bids him forward." It rings in the song after defeat as well as in the shoutings of victory.

It is progress and purpose and pluck and prayer, though certain of these aspects reveal themselves only upon analysis somewhat refined. It owns the college, loves the college, runs the college. Let this be the spirit of Rice.

If I have adequately described this incense of college spirit as it rises from the college campus, all that I have said and a great deal more is necessary properly to characterize that informing spirit of the college itself whose sources are in conference, cloister, and council-chamber. This informing spirit is more than opinion and impulse and enthusiasm, though inspired and directed by each of them in turn. It is more than tradition and custom and law, though continually molded by all three. It is the spirit of science and the spirit of service. Sustained by such hard and homely supports as concentration of study, co-ordination of studies, co-operation of students, and capitalization of student activities, its life is continually renewed by the native and unceasing demands of the human spirit for the sweetness and light of culture, for the strength and charity of character, for the law and order and security of enlightened citizenship. It is the brain of the college, the heart of the college, the soul of the college. May this also be the spirit of Rice.

There is nothing unusual in insisting that the spirit of one's college is democratic. Every college in the country contends that it has the spirit of true democracy; the only difference, if any, is that here we do have it. It is equally true that every good thing in college life has been a subject of criticism, and this is well, for criticism is the way to health, while complacency may be on the way to stagnation. No feature of organized college life has been the subject of greater criticism than the organized devotion to athletic sports, both in the college and among the colleges. In climatic conditions where outdoor life is easily possible

throughout the year, the new institution will have to face its problems in athletics resolutely. This will be the more necessary because we believe to a man in outdoor sports; for quite as important to the student as his home and standards, as his habits and studies, are his hobbies and his sports. We used to advocate athletics to make the boy a man; we now advocate athletics to keep the man a boy. Youth! eternal youth! lived in a fountain of perpetual youth! This is one of the great compensations of the academic life. Generations of college men may come and generations go, but youth, joyous and eternal in its spirit, runs on through all these comings and goings. And this contagion has spread beyond the academic atmosphere, for everywhere there is the determination to die a hundred years young. This determination is best realized through systematic and regular physical exercise: it may be throwing the discus, hurling the hammer, putting the shot, wielding tennis racquet or golf stick, participating in football, baseball, and other sports in season, felling trees, driving a motor-car, or steering an airplane. Equally advantageous is a similar system of mental gymnastics to discipline the intellect and stimulate the imagination by some serious study wholly independent of one's vocation: for example, the Iliad or Euclid, the *Principia* or the *Novum Organum*. However, inasmuch as we do no less of our thinking with our hearts than with our heads, it becomes imperative that the springs of our impulses be kept strong and pure. That is to say, the emotions must be held sane and normal; this equilibrium is perhaps best maintained by interest or skill in art. A study and a sport and a song! Personal prejudice might lead me to suggest mathematics, meadow-running across country, and music. In conclusion, and on the mighty element of this triad, the great defense of college sports is that sane devotion to them which leads not

only to healthy living but to clean living. The dangers lie in over-training, in high specialization, in professional tendencies in the highly developed team, making sport for the few and spectators of the many. The problem is to get the student crowds off the bleachers and in the blazers. Some of these difficulties we hope to meet by giving athletic training a place in the curriculum, by encouraging class, club, and college competitions, by fostering the sportsman's spirit of amateur sport in all meets—a temper which I can perhaps best express by quoting the following striking and appropriate lines from a short poem by Mr. Henry Newbolt, entitled "Clifton Chapel," which appeared in the "Spectator" of September 10, 1898:

To set the cause above renown,
To love the game beyond the prize,
To honour while you strike him down
The foe that comes with fearless eyes.
To count the life of battle good,
And dear the land that gave you birth,
And dearer yet the brotherhood
That binds the brave of all the earth.

In thus writing about the students of Rice, I have written of their standards, their spirit, and their sports; I have yet to write, and as briefly as possible, of their studies, their shields, and their songs. I have told these students—these outriders of a host, these torch-bearers of the sun-dawn, these conquerors of a new day, these forerunners of a throng that is ultimately to be many thousand strong—these first students of the Rice Institute, I have told them that they are the Rice Institute. These beautiful buildings are its tenement of clay, but the staff and students its brain and heart, determining and regulating the flow of thought and the flow

of life in its being: in them its character and intellect, its standards in scholarship and sports, assume concrete form; in them its spirit and temper find a body; without their presence these quadrangles would be empty, these halls silent; without their co-operation these plans would become ineffective, these programmes unfulfilled. But with their help, which they have given heartily, and with their hopes, which well up constantly, the dry bones of an academic programme are coming to life, and these dry bones live. Probably the most joyous expression of that life will find itself in the songs of the students. These songs, inarticulate in our hearts, will one after another be called to vocal expression by the great days and crises of our life. We shall have our "Fair Harvard," "Old Nassau," "Hail, Pennsylvania," and "The Eyes of Texas are upon You." With Yale men we too shall sing of this "Mother of Men," and to "Alma Mater" with Stanford, Johns Hopkins, Chicago, and Cornell. Under the Lone Star of Texas and the Owls of Rice, under the Blue and Gray floating from their standards—a blue still deeper than the Oxford blue, and the gray of Confederate days warmed into life by a tinge of lavender—they shall sing their songs; sing of jasmine, magnolias, and roses, poinsettia and violets blue; they shall cheer their teams and their heroes for the deeds of valor they do in field or forum or class-room; for Rice and for Houston and Texas they shall cheer and shout and sing—sing of campanile stately and their college near the sea, sing of sunset on the prairie, of the moonrise through the pine-trees, of the Spanish moss and liveoak, of the Quad's fair towers and cloisters, of undying loyalty; songs of sentiment and devotion giving rise to songs of service, inspired by the device on their banner, a Homeric device,

Αἰὲν ἀριστεύειν καὶ ὑπείροχον ἔμμεναι ἄλλων,

a line appearing twice in the Iliad at vi, 208, and xi, 784, said to have been the favorite of Alexander the Great and used by him to exhort his men on the great expedition; a device borne also as *αἰὲν ἀριστεύειν* by the students of St. Andrews, who, in the days when we were laying the foundations of this building, were celebrating the five-hundredth anniversary of the founding of their own university. In the longer of Pope's two translations the line reads:

To win renown,
To stand the first in worth as in command;
To add new honours to my native land;
Before my eyes my mighty sires to place,
And emulate the glories of our race.

And on the flag of these Rice students are two shields, a shield of the State of Texas and the shield of the Rice Institute. The latter heraldic device was designed by Mr. Pierre de Chaignon la Rose of Cambridge, Massachusetts, who has ingeniously combined the main elements of the arms of the several families bearing the names of Rice or Houston. The problem was simplified by the fact that the shields of some ten Rice armorial bearings were always divided by a chevron, always carried three charges, and when these charges were not crows they were ravens. Curiously enough, the shields of the half-dozen Houstons who bore arms were always divided by a chevron, while here again the three charges were birds, and these were always martlets. Accordingly it was decided to employ a double chevron, and since neither the crow nor the raven nor the martlet had any historical academic standing, owls of Athena were chosen for charges, and in the remarkable form in which they appeared on a small silver tetradrachmenon of the middle of the fifth

century before Christ. The choice of colors was rather more difficult, and is a long story; but to make that long story short, among the several ends to be desired were, that the combination of colors should be stable, should not trespass upon the five or six hundred combinations already chosen by other institutions, should harmonize with State and national emblems for purposes of decoration on gala occasions, should be standard colors easily and economically procurable, and finally they should jump with local climatic conditions—that is to say, plenty of color and yet cool in the warm sun of summer, delicate and yet of sufficient life if days should perchance be dull. At least some of these ends were attained in the combination of blue and gray described in the preceding paragraph, namely, the Confederate gray enlivened by a tinge of lavender, with a blue still deeper than the Oxford blue.

In an earlier section of this address I have sketched in broad lines the scope of the new university's work and the range of its studies. I have implied our belief that the college and the professional school thrive best in a university atmosphere. I have also said that this university programme with us is to have no upper limit, and that its lower limit is to be no lower than that of the more conservative colleges and universities of the country; that is to say, the Rice Institute's programme will include within its schedules of studies no courses of grade lower than collegiate grade. The opportunity to found a great secondary school, as was the opportunity to devote the entire resources of the foundation to a single professional school, was tempting and equally promising. Neither of these courses, however, would have kept full faith with the will of the founder as expressed in the charter and testament, nor would either have served the city and the State quite as fully as the one finally adopted.

Accordingly it is as a university that the Institute proposes to begin, a university of liberal and technical learning, where liberal studies may be studied liberally or technically, where technical subjects may be pursued either technically or liberally, where whatever of professional training is offered is to be based as far as possible on a broad general education.

Candidates for admission to the Institute who present satisfactory testimonials as to their character will be accepted either upon successful examination in the entrance subjects or by certificate of graduation from an accredited public or private high school. The terms of admission to the Institute are based on the recommendations of the Carnegie Foundation for the Advancement of Teaching as expressed in the Documents of the College Entrance Examination Board. While seeking to develop its students in character, in culture, and in citizenship, the Rice Institute will reserve for scholarship its highest rewards, and in particular for evidences of creative capacity in productive scholarship. To encourage this devotion to learning a series of undergraduate scholarships and graduate fellowships will be devised, to be awarded preferably to those students who have been in residence at the Institute for at least one year. Moreover, the varied opportunities for self-help in a growing institution in a large city should aid in enabling any young man of determination to earn his education in a thoroughly democratic college community. There may thus be realized the founder's desire that the advantages which his philanthropy would make possible should be brought within the reach of the promising student of slender means.

Although it is the policy of the new institution to develop its university programme rather more seriously from the science end, there are also being provided facilities for elementary and advanced courses in the so-called humanities,

thereby enabling the Institute to offer both the advantages of a liberal general education and those of special and professional training. Extensive general courses in the various domains of scientific knowledge are available, but in the main the programme consists of subjects carefully co-ordinated and calling for considerable concentration of study. These programmes have been so arranged as to offer a variety of courses in arts, in science, in letters, and in their applications to the several fields of applied science, leading after four years of undergraduate work to the degree of bachelor of arts. Degrees will also be offered in architecture and in chemical, civil, electrical, and mechanical engineering. Furthermore, for the degrees of master of arts, doctor of philosophy, and doctor of engineering every facility will be afforded properly qualified graduate students to undertake lines of study and research under the direction of the Institute's resident and visiting professors. Thus it appears that Rice would interpret in a very large way its dedication to the advancement of letters, science, and art. It would look not only to the employment of these principles in the development of the life of the individual and in that of the race, but it would also play its part in the progress and enlargement of human knowledge by the contributions of its own resident professors and scholars. We believe that to this end there should be a constant and close association of undergraduate work and postgraduate work, that any proposals which would tend to their separation would be injurious to both. "A hard and fast line between the two is disadvantageous to the undergraduate, and diminishes the number who go on to advanced work. The most distinguished teachers must take their part in undergraduate teaching, and their spirit should dominate it all. The main advantage to the student is the personal influence of men of original mind. The main

advantage to the teachers is that they select their students for advanced work from a wider range, train them in their own methods, and are stimulated by association with them. Free intercourse with advanced students is inspiring and encouraging to undergraduates. The influence of the university as a whole upon teachers and students, and upon all departments of work within it, is lost if the higher work is separated from the lower." Accordingly, there should always be associated with the staff of the Institute a group of advanced students in training for careers both as teachers and researchers: with this end in view, graduate fellowships will be awarded from time to time to degree-bearing students of the Institute or other educational foundations of similar standing. As a matter of fact, in the academic year 1914–15 there are in residence two fellows in mathematics, two in physics, and one in biology.

The academic schedules of study drawn up in the immediately succeeding sections of this address had not been prepared in detail when the address was being written. They have grown gradually into form out of the general and local experience of the faculty of the Institute. They are taken from preliminary announcements, to which they were contributed on recommendation of the staff after discussions of proposals submitted by a committee on studies and schedules consisting of Messrs. Axson, Evans, Guérard, Huxley, and Wilson, resident members of the faculty.

The programmes of courses leading to the degree of bachelor of arts after four years of study are of a common type for the first two years, but for the third and fourth years are differentiated into two forms: first, general courses leading to the degree of bachelor of arts, either with some grade of distinction or without special mention; second, honors courses leading to the same degree with first, second, or

third class honors. These two types will be referred to in the sequel as general courses and honors courses, respectively. The general course leading to the degree of bachelor of arts has been arranged to give thorough training to those students who are seeking university instruction in literary and scientific subjects either as a part of a liberal education or as preliminary to entrance upon a business or professional career. The general course therefore involves the study of several subjects up to a high university standard, but does not include a highly detailed specialized study of any one subject such as is necessary before research work or university teaching can be profitably undertaken. Students wishing to specialize with a view to research work and university teaching may either take an honors course and then proceed by graduate study to the degrees of master of arts and doctor of philosophy, or they may first take a general bachelor of arts course and after completing it proceed by graduate study to the higher degrees.

The attention of students intending to enter the profession of engineering or architecture will be constantly called to the great advantages in first taking a general or honors course before beginning special study in engineering or architecture. As a matter of fact, the time is coming when in the South there will be demand for a place where a bachelor's degree will be required for admission to courses in engineering and other domains of applied science, and when that time comes the Rice Institute intends to occupy that place. However, in the face of present local conditions such a severe standard can only be reached through an evolutionary process that may occupy a score of years or a generation. For the present the Institute will not offer courses leading to professional degrees in law and medicine, but students looking forward to such careers will find in the earlier years of

the bachelor of arts courses all the requirements for admission to many medical and law schools, provided suitable subjects are chosen. However, in view of the fact that several of the leading professional schools of law and medicine are now requiring a bachelor's degree for admission, all such students are urged to proceed to this degree before entering upon specialized study preparatory to the practice of their profession.

To students of architecture the Institute offers a full course extending over five years, leading to the bachelor's degree at the end of the fourth year and to an architectural degree at the end of the fifth year. It is the purpose of the course in architecture to lead men during their residence to a comprehensive understanding of the art of building; to acquaint them with the history of architecture from early civilization to the present age; and to develop within them an understanding and appreciation of those conceptions of beauty and utility which are fundamental to the cultivation of ability in the art of design. The course has been so arranged as to include certain indispensable elements of liberal education and also such engineering and technical subjects as are becoming more and more necessary to the general education of a practising architect. Of the more strictly architectural subjects, design is given by far the largest place. As a matter of fact, the courses in history and design and those in free-hand drawing, in water-color, in drawing from life, and in historic ornament have all a double object: to create in the student an appreciation of architectural dignity and refinement, and to increase constantly his ability to express conceptions of architectural forms. Accordingly the training of the student must not be limited to the training in draftsmanship alone, but all courses should conspire to the cultivation of creative and constructive ability in expression

and design. With a view to keeping in touch with the progress of his profession and with the daily routine and detail of its practice, it is strongly recommended that the student spend his summer vacations in the office of some practising architect.

Courses will be offered in chemical, civil, electrical, and mechanical engineering. A complete course in any one of these branches will extend over five years. A student who has successfully completed the first four years of a course will be awarded a bachelor's degree, and after successfully completing the remaining year of his course he will receive an engineering degree. The work of the first three years will be practically the same for all students, but in the last two years each student will be required to select one of the special branches mentioned above. The work of the first two years will consist chiefly of courses in pure and applied mathematics, physics, chemistry, and other subjects, an adequate knowledge of which is absolutely necessary before the more technical courses can be pursued with advantage. During the first two years, however, a considerable amount of time will be devoted to engineering drawing and the elements of surveying. Technical work will begin in the third year[1] with courses of a general character in mechanical engineering, civil engineering, and electrical engineering, all three to be taken by all engineering students, including those in chemical engineering. These courses will form an introduction to the technical side of each branch, and should enable students intelligently to select a particular branch at the beginning of their fourth year. In the third year instruction will also be begun in shopwork. The classes in shopwork are intended

[1] As a matter of fact, during the present academic year (1914–15) members of the junior class are receiving lecture and laboratory courses of general and introductory character in engineering and architecture at the hands of Messrs. Diamant, Hitch, Humphrey, Pound, Tidden, Van Sicklen, and Watkin.

to give familiarity with shopwork methods. The object of these classes is not primarily to train students to become skilled mechanics, but to provide such knowledge of shop methods as is desirable for those who may be expected as engineers to employ mechanics and to superintend engineering shops. It is intended in the engineering courses to pay special attention to the theoretical side, because experience has shown that theoretical knowledge is difficult to obtain after leaving the university, and without it a rapid rise in the profession of engineering is almost impossible. On the other hand, it is not intended to disregard practical instruction. For this reason the last three years will include, besides shopwork, a variety of practical work in engineering testing-laboratories. It is recommended that students obtain employment in engineering work during the summer vacations, for it should be remembered that no amount of university work can take the place of learning by practical experience in engineering establishments and in the field. The courses in engineering are not intended to take the place of learning by practical experience, but are designed to supply a knowledge of the fundamental principles and scientific methods on which the practice of engineering is based, and without which it is difficult, if not impossible, to succeed in the practice of the profession. Students who can afford the time are recommended to devote three or four years to preliminary work instead of two, taking the bachelor of arts degree at the end of four years and an engineering degree at the end of six years. Students proposing to do this are advised to take a course devoted largely to mathematics, physics, and chemistry, or an honors course in either mathematics, physics, or chemistry. The subjects taken during the years of preparatory work must include those of the first two years in the general engineering course, which may be

substituted for electives in the academic bachelor of arts course. The honors course in physics is strongly recommended for those who wish to become either electrical or mechanical engineers.

As has already been intimated, the course for the degree of bachelor of arts extends over four years. During the first two years a considerable part of the work is prescribed, while during the last two years each student is allowed, with certain restrictions, to select the subjects he studies. In the majority of the courses the formal instruction offered consists of three lectures a week, on alternate days, together with laboratory work in certain subjects.

The academic year is divided into three terms, but as a rule the year is the unit of the courses rather than the term. In addition to informal examinations held at irregular intervals, there are formal examinations at the end of each of the three terms. In determining the standing of a student in each class, both his work during the term and the record of his examinations are taken into account.

Of subjects included in the bachelor of arts course the following are now available:

Group A: English, French, German, Spanish, economics, education, history, philosophy, architecture.

Group B: pure mathematics, applied mathematics, physics, chemistry, biology, chemical engineering, civil engineering, electrical engineering, mechanical engineering.

Instruction in the classics is also offered on demand.

Candidates for the degree of bachelor of arts of the Rice Institute are required for the first two years of their course to select studies from the preceding groups according to the following yearly programmes. First year: pure mathematics, English, a modern language, a science, and one other subject. Second year: pure mathematics or a science, Eng-

lish, a modern language, and two other subjects. Students who enter with credit in two modern languages may substitute another subject for modern languages in the second year. At the beginning of the third year students may elect to take either a general course or an honors course. The third year general bachelor of arts course consists of four subjects, of which two must have been taken in the second year and one in both first and second. At least one subject from each of the groups A and B must be taken. Students will receive advice in the selection of their subjects. The fourth year general bachelor of arts course includes four subjects, two of which must have been taken in the third year and one in both second and third. At least one subject from each of the groups A and B must be taken. To students who have completed the general course the bachelor of arts degree will be awarded either with some grade of distinction or without special mention. The third and fourth year honors courses are intended for students who wish to specialize in particular branches of knowledge with a view to research work or teaching or later professional studies. In view of these special objects, the requirements in such courses will be more severe than in the general courses in the same subjects. For this reason it is recommended that students exercise due caution and seek advice before electing to take an honors course. Only those students who have shown in their first and second years that they are especially well qualified will be permitted to take an honors course. A student proposing to take such a course must satisfy the department concerned that he is qualified to proceeed with the study of that subject. He will be required to take the lectures and practical work provided for honors students in that subject during each of the two years, and in addition certain courses in allied subjects. The degree of bachelor

of arts with first, second, or third class honors will be awarded, at the end of the fourth year, to students who have completed an honors course. Honors courses in mathematics and physics were given during the academic year 1913–14. In 1914–15 honors courses will be available in pure and applied mathematics, and theoretical and experimental physics. In addition to these, honors courses in modern languages and literatures and in biology will be offered in 1915–16.

A student who has completed a general or an honors course for the bachelor of arts degree may obtain the master of arts degree after the successful completion of one year of graduate work. A candidate for the degree of master of arts must select a principal subject and will be required to take such courses in that subject and allied subjects as may be determined for each individual case. He will also be expected to undertake research work under the direction of the department of his principal subject, and must submit a thesis embodying the results of his work. A student who has completed a general course for the bachelor of arts degree may obtain the degree of doctor of philosophy after not less than three years of graduate study and research work. A student who has obtained the bachelor of arts degree with first or second class honors may obtain the doctor of philosophy degree after not less than two years of graduate study and research work. Candidates for the degree of doctor of philosophy must submit a thesis and pass a public examination. For the year 1914–15 graduate courses will be given in biology, pure and applied mathematics, and theoretical and experimental physics.

From the preceding systematic schemes for academic and scientific work, it would appear that the Rice Institute aspires to university standing of the highest grade as an institution

of liberal and technical learning, dedicated to the advancement of letters, science, and art, by instruction and by investigation, in the individual and in the race, its opportunities for study and research being open, without tuition and without fees, both to young men and to young women. Moreover, to recapitulate more broadly, the new university, subject neither to political nor to sectarian affiliations, is governed by a self-perpetuating board of seven trustees, elected for life. Under a definite educational policy and comprehensive architectural plan, it is being built and maintained out of the income of its funds of approximately ten million dollars for endowment and equipment. On its campus of three hundred acres, in a half-dozen initial laboratory, lecture, and residential buildings of extraordinary beauty, there are at work in the academic session of 1914–15 a teaching staff of some thirty members, all inspired by the spirit of research, maintaining highest standards of entrance requirements and of scholastic standing after admission, offering university courses in liberal arts, pure and applied science, architecture and engineering; a small group of graduate students in mathematics, physics, and biology; a self-governed democratic undergraduate body of freshmen, sophomores, and juniors, of more than two hundred and fifty members, from some seventy-five towns in Texas and fifteen States of the Union, the first freshman class having been received in September, 1912, to earn the first degrees, which will be conferred in June, 1916.

VII

THE UNIVERSITY: ITS SHADES AND TOWERS

NO sketch of the university's programme, however slight, would be complete without some descriptive account of the general architectural plan, according to whose principles of beauty and utility students and staff are to be provided with theaters of action, groves for reflection, laboratories of discovery, libraries of knowledge, fields for sport, halls for speech and song, homes for complete living, and all dedicated to the freedom of sound learning and the fellowship of youth. At the risk of repetition, several details of this rather ambitious scheme will now be recited.

It is not difficult to plan for fifty years, nor is it difficult to plan for five years: difficulty enters only when it is necessary to plan at one and the same time for the immediate future and for the next hundred years. The problem is to design a scheme which is so flexible as to be capable of indefinite expansion along prescribed lines of educational policy and physical environment, and which at the same time is sufficiently compact and so closely articulated as to be comfortably and economically efficient in the earlier stages of its development. The plan about to be described briefly is an evolution out of some thirty-five or forty preliminary studies. In its final form it is believed to represent with fidelity the educational programme of the new institution, and to meet, with some measure of success, the demands of local geography, subsequent growth, initial harmony, and final unity.

Behold a campus of three hundred acres, a tract as irregular in form as if purchased in Boston, with four thousand

feet frontage on the Main Street of Houston. Unfold the map we have made, for a great deal of the meaning of this new institution appears in its lanes and lawns, its walks and drives, its cloisters and retreats, its playing-fields and garden courts, its groups of residential halls for men, its halls of residence for women, its gymnasium, and stadium, and union, its several quadrangles of laboratories in science pure and applied, its schools of liberal arts, of fine arts, of mechanic arts, its chapel and choir, its lecture-halls and amphitheaters, its Greek playhouse and astronomical observatory, its great hall with library and museum wings, its graduate college of research and professional schools. Of the four main entrances to the three-hundred-acre campus, the principal one lies at the corner of the grounds nearest the city. From this entrance the approach to the Administration Building is a broad avenue several hundred yards long, ending in a fore-court, which will be bounded on the left by the School of Fine Arts, on the right by the Residential College for Women. The main avenue of approach coincides with the central axis of the block plan, and from the principal gateway opens up through the vaulted sally-port of the Administration Building a vista of more than a mile within the limits of the campus. After dividing at the fore-court the driveway circles the ends of the Administration Building and continues for half a mile in two heavily planted drives parallel to this axis and separated by a distance of seven hundred feet. Within the extended rectangle thus formed the pleasing effect of widening vistas has been realized. On passing through the sally-port from the fore-court, the future visitor to the Institute will enter upon an academic group consisting of five large buildings, which with their massive cloisters surround on three sides a richly gardened court measuring three hundred by five hundred feet, planted in

graceful cypresses. Beyond this group is another academic court of still greater dimensions planted in groves of live-oaks; this Great Court in turn opens into extensive Persian gardens beyond which the vista is closed at the extreme west by a great pool and the amphitheater of a Greek playhouse. The principal secondary axis of the general plan, starting from the boulevard and running north perpendicularly to the main axis, crosses the lawns and courts of the Liberal Arts and Science groups into the Mechanical Laboratory and the Power-house, the first buildings of the Engineering Group. The fourth entrance on Main Street leads to the athletic playing-fields and the Residential Colleges for Men. While each unit of the latter group has its own inner court, the several buildings themselves together inclose a long rectangular court bounded at the eastern end by a club-house, an adaptation of the Oxford Union, and on the west by the Gymnasium, which opens on the Athletic Stadium in the rear. North of the men's residential group and across the Great Court, lying between the Botanical Gardens and the Laboratories of Pure and Applied Science, appear the splendid quadrangles of the Graduate School and its professional departments; south and west of the latter quadrangles will rise the domes of the Great Hall with its Library and Museum wings, and the Astronomical Observatories, respectively.

Although designed to accommodate the executive and administrative offices when the Institute shall have grown to normal dimensions, the Administration Building will be used during the first few years to meet some of the needs of instruction as well as those of administration. The building is of absolutely fire-proof construction throughout; it is three stories high, three hundred feet long and fifty feet deep, with a basement running its entire length. Through a cen-

tral tower of four stories a vaulted sally-port thirty feet high, leading from the main approach and fore-garden to the academic court, gives entrance to the halls of the building and opens the way to the broad cloisters on the court side. On the first floor, besides offices of registration, there are lecture-rooms, class, study, and conference rooms. In the north wing of the second floor the temporary plans make adequate arrangements for library and reading-rooms; the second and third floors of the south wing are given to a public hall, which, with its balconies, extends to the height of two stories. A little later on in the history of the Institute this assembly hall will become the faculty chamber. The remaining part of the third floor provides additional space for recitation and seminar rooms, and offices for members of the teaching staff. The meeting-room of the Board of Trustees and the offices of the President of the Institute are located in the tower.

In its architecture the Administration Building reveals the influence of the earliest periods of the Mediterranean countries: vaulted Byzantine cloisters, exquisite Dalmatian brickwork, together with Spanish and Italian elements in profusion; all in a richness of color permissible only in climates similar to our own. The dominant warm gray tone is established by the use of local pink brick, a delicately tinted marble from the Ozark Mountains, and Texas granite, though the color scheme undergoes considerable variation by the studied use of tiles and foreign marbles. To meet the local climatic conditions the building has been pierced by loggias and many windows, while its long shaded cloister opens to the prevailing winds. The corner-stone of this monumental structure was set in place by the trustees of the Institute on the seventy-fifth anniversary of Texas independence.

Two wings of the first building in the students' residen-

tial group for men are now ready for occupancy. This quadrangle, consisting of a dormitory and a commons, is placed southwest of the Administration Building, its front approach leading from the fourth campus entrance on the Main Street boulevard. The residential wings are long three-story fire-proof structures with towers of five stories, broad cloisters on the front, and basements extending the entire length. Each wing opens upon a garden on one side, and on the other upon its own court. In arrangement and equipment the buildings are modern and in every way attractive and convenient. Accommodations for about two hundred students are offered in single and double rooms and suites. Lodgings have been provided for several preceptors, and two large halls have been set aside for the temporary use of literary and debating societies. The floors of the wings are so planned as to insure for every room perfect ventilation and absolutely wholesome conditions. There are lavatories, shower-baths, and sanitary connections adequate to the needs of each floor; the power for both light and heat will be received from the central plant. An arcade rather more than one hundred feet in length leads from the dormitory wing across the inner court to the commons which constitutes the northern boundary of the quadrangle. The commons proper includes every detail necessary for the perfect service of all the men living in the residential group and at the same time is of sufficient size and capacity to serve other members of the student body. In addition to the dining-hall and its equipment, this section of the building contains club and reading rooms. It is graced also by a handsome clock-tower, four stories high, surmounted by a belfry: the several floors of the tower have been arranged in suites of rooms to be reserved for the use of graduate students and instructors. As has been intimated already, the other buildings under

way propose to reveal in brick and marble some of the more subtle suggestions of the southern architecture of Europe and the East, and at the same time to realize the fundamental principles of their sources in a distinctive style of academic architecture for all the future buildings of the Institute. Consistent with the architectural style thus evolved, a pleasing and harmonious variation appears in the treatment of the first residential group, whose several towers and cloisters in brick and stucco are designed to produce an effect characteristically Venetian.

Located at the northern end of the principal secondary axis of the general architectural plan are groups of scientific and technical laboratories. The first buildings of this section of the campus, namely, the Mechanical Laboratory, Machine-shop, and Power-house, have been erected north of the Administration Building at the end of a long direct driveway from the third Main Street entrance. The Laboratory, a two-story fire-proof building two hundred feet long and forty feet deep, with a cloister extending the full length of its court side, is built of materials similar to those used in the construction of the Administration Building. The space of its floors will be given to scientific laboratories, lecture-halls, recitation-rooms, departmental libraries, and offices for instructors in charge, while its basement will afford additional room for further apparatus. Through the Machine-shop the Mechanical Laboratory connects with the Power-house, where is installed equipment for complete steam, refrigerating, and electric generating and distributing systems. The lofty campanile of this group, visible for miles in every direction, will probably be for many years the most conspicuous among the towers of the Institute.

Further improvements of the campus are being gradually effected. An extensive concrete water-proof tunnel has been

constructed to transmit power—water, steam, electricity, heating, and cooling—from the central plant to all the buildings on the grounds. With a diameter sufficient to admit a man standing erect, the tunnel has ample space for all wiring and piping in positions easy of access, thus insuring perfect care of the equipment and a resultant increase in efficiency. Progress has also been made in the installation of complete sanitary and drainage systems, which, with an unlimited supply of wholesome water, should give assurance of perfect physical conditions at the site of the Institute. The most important driveways, including the main approach to the Administration Building, the drives along the axes leading to the group of scientific laboratories and to the students' residential group, and the long roads inclosing the academic court, have been laid on deep foundations of gravel with surfacing of crushed granite. The planting of double rows of oaks, elms, and cypresses along these drives, and the assembling of hedges, shrubs, and flowers within the gardens and courts of the present groups, will subsequently impress even the casual visitor both with the magnitude and with the beauty of the general architectural plan.

VIII

THE UNIVERSITY: ITS STRENGTH AND SUPPORT

"'TIS not the walls that make the city, but the men"; and the men in the day of Pericles were freemen who "pursued culture in a manly spirit, and beauty without extravagance." Such freemen are the men that build the university. The strength of this foundation lies in its freedom: the freedom to think independently of tradition; the freedom to deal directly with its problems without red tape; the freedom to plan and execute vouchsafed by the will of the founder and the charter of his foundation; the freedom of his seven trustees, seven freemen, who approach its problems of organization, policy, and aim, without educational prejudices to stultify, without partisan bias to hinder, without sectarian authority to satisfy, with open minds accustomed to large problems, with clear heads experienced in tracking the minutest details of business; seven men always ready to reason together, steady and conscientious in reaching conclusions, quick and decisive in action when through common counsel they have come to a common mind respecting any line of action. Indeed, in no circumstance has the new institution been more fortunate than in the circumstance that the foundation and its future are held in trust by a half-dozen Texans, men who have the blood of the pioneers in their veins, the purpose and courage of the pioneers in their hearts, themselves successful men of affairs, who with the characteristic mindedness imposed by the magnitude of the State itself, desire only the best, seek only the best, and think in none but large terms of any problem or enterprise.

For this reason it is easy to dare and to do great things in Texas, for the men who have been winning this empire are to a man dominated by imperial ideas for it. The dominant idea of these trustees is that here in Texas there should arise an institution great for the future of Texas. Believing that the best is none too good for the sons and daughters of Texas, and determined to give to Texans a better Texas, these men have not hesitated to command the services of men and material and machinery whenever and wherever the best of such services was to be commanded. And in their freedom these trustees are building for the founder a university whose greatest strength likewise is in its freedom: in the freedom of its faculties of science, humanity, and technology, to teach and to search—each man a freeman to teach the truth as he finds it, each man a freeman to seek the truth wherever truth may lead: in the freedom to serve the State because entangled in no way with the government of the State, and the freedom to serve the Church because vexed by none of the sectarian differences that disturb the heart of the Church.

While we rejoice in our freedom from Church or State control, we rejoice none the less in the work of these fundamental and indispensable agencies of civilization, for we can conceive of no university in whose life there does not appear the energy and enthusiasm, the affection and the calm, that we associate in one way or another with reverence, patriotism, politics, and religion. Hence to us, quite as important as is a university's freedom from control by State or Church, are its right relations to each of these two institutions, because upon principles of order, conduct, and knowledge is based our faith in the capacity of the human spirit for progress, and without such basic faith all theories of education become either confused or futile. As a matter of fact, any

civilized life of men in communities of culture and restraint does demand for its very existence the three great fundamental requirements I have just named—order, conduct, knowledge; and these three primary requisites find their expression in the forms of three great institutions—the State, the Church, and the University. These institutions themselves are not fixed and final but fluid and forming, constantly in the flow of change, in transition from good to better, to meet new requirements of a changing world and a growing humanity. In their present mutual relations, the State, the master of the sword and peace; the Church, the mistress of the soul and purity; the University, the servant of each of them in preserving to men the mastery of their spirits. The State guaranteeing to the University intellectual freedom, to the Church religious freedom; the University in freedom of thought and research constantly enriching the State with the theory of its own greatness, constantly recalling the Church to the theories of life wherein all men are made free; the Church in its turn sustaining the Nation and supporting the University in high ideals of progress and ultimate triumph. These three institutions constitute the triple alliance of civilization: the patriot, the priest, and the professor, the great triumvirate of progress, preserving to citizen, saint, and scholar political freedom, intellectual freedom, religious freedom, guaranteeing to all liberty in the pursuit of happiness, liberty in the pursuit of knowledge, liberty in the pursuit of heaven. This threefold freedom, this threefold liberty, brings to citizen, saint, and scholar corresponding obligations. Their greatest obligation, greatest service, individual and collective, to the State is to enlighten public opinion; to the Church, is to conserve faith; to the University, is to save the human race through universal education, universal but not necessarily uniform,

voluntary where possible, compulsory when necessary, competitive and selective always.

These obligations the State and the Church have made noble efforts to meet in Texas. From the early days of the Republic the Church has been the founder of colleges and the State the patron of learning. Each is constantly seeking for its institutions the means for better equipment, for larger endowment, for greater efficiency in service.[1] We honor the

[1] In most recent days, on the initiative and faith of one man, Mr. Will C. Hogg of Houston, an alumnus of the University of Texas and son of a distinguished governor of this commonwealth, there has been formed and endowed, under the auspices of the University of Texas Alumni Association, of which Mr. Edwin B. Parker of Houston is president, an Organization for the Enlargement by the State of Texas of Its Higher Institutions of Learning. This so-called Hogg Organization is prosecuting its work under a Board of Control of which Dr. Sidney E. Mezes, president of the University of Texas, is chairman, Mr. F. M. Bralley, State superintendent of public instruction, is executive secretary, and Mr. Arthur Lefevre, formerly State superintendent of public instruction, is secretary for research. Among the objects of the present programme of this organization is the education of public opinion, from platform, press, and pulpit, by frank accounts of the present equipment of the educational institutions directly under the patronage of the State of Texas, and by comparative studies based on the history of the State institutions of other States of the Union. This movement has as its final object—and this final object is bound in time to be attained—the removal of all the State-supported educational institutions, namely, the Agricultural and Mechanical College of Texas, the College of Industrial Arts, the several State Normal Schools, and the University of Texas, entirely from the sphere of political influence, and their relief from the necessity of depending on appeals to the legislative bodies of the State government for periodical appropriations to meet expenses of maintenance and equipment.

And the denominational institutions are keeping pace. The Baptists, with the help of a donation from the General Education Board of the Rockefeller Foundation, are adding substantially to the endowment of Baylor University under the leadership of President Samuel P. Brooks; the Christians, burnt out at Waco, are building at Fort Worth a new Texas Christian University under the presidency of Dr. Frederick D. Kershner; the Methodists are adding to the resources of Southwestern University at Georgetown under President Charles M. Bishop, and with the assistance of an appropriation from the Rockefeller Foundation are building in Dallas a new institution to be called the Southern Methodist University, with Dr. Robert S. Hyer as president; while the Presbyterians are rebuilding Austin College at Sherman under President Thomas S. Clyce, are seeking increased endowment for Trinity University at Waxahachie under President Samuel L. Hornbeak, and, under the leadership of the president of their educational board, Dr. Robert E. Vinson of Austin, are proposing to add at least one new college to their list of institutions in Texas. Moreover, at the Rice Institute we have already felt the influence of the educational institutions maintained by the Catholic Church at Dallas, Galveston, Houston, San Antonio, and other points in Texas, and we have also felt a similar influence on the part of the Hebrew faith which has not been lacking in stimulating the development of education and the advancement of learning in Texas.

State and the Church for the work they have done. Even more do we honor them for the greater work they are proposing to do, for education in Texas. We modestly but confidently hope to aid them in this work, for it would be pleasant to think that this new university in Texas is the best thing that could have happened to every other university of Texas. The pioneers believed in education for all the people as the surest safeguard of their free institutions. Said Sam Houston, "The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government." Said Mirabeau B. Lamar, "Cultivated mind is the guardian genius of democracy. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire." With these pioneers we their successors believe that in the character of the cultivated citizen lies the strength of the civilized State. In writing thus a cardinal article of our creed I have used the phrase "cultivated citizen" deliberately and advisedly. I am quick to take off my hat to the self-made man, and among people so democratic as is this people there will never come a time when any door of opportunity will be closed to him. But the race with the college-trained man the self-made man is finding a race severer and severer. Even as recently as a decade ago the college man was compelled to defend the course he had pursued, but more lately, in business as in professional life, his demonstrated and enduring potentialities have been steadily and surely placing him in the lead. Nor in public life has it come to pass by accident in our national history, that the leading candidates in the last two presidential campaigns should have been graduates of Harvard and Yale, respectively, and the three leading candidates in the present presidential campaign be graduates, respectively, of the oldest, the next oldest, and

the next to the next oldest of American colleges, Theodore Roosevelt of Harvard, William Howard Taft of Yale, and Woodrow Wilson of Princeton. That our best trained men are showing a growing disposition to enter earnestly into political life, is a most encouraging sign for the future of our government. For an increasing number of our men of education are entering the field of public life to possess it for the common weal, and they are transforming it into a place where men may take up their residence, live honestly, and be held in honor. In disinterested public service they are transforming the politics of the professional politician, whose problems are sometimes mean, into the politics of the statesman and patriot, whose problems are always large. I believe in holding up careers in practical politics as inviting ones to vigorous young men of broad academic training, men of the same fiber and stuff and consecration as are those who turn their backs on remunerative callings and possible commercial success to enter the ministry and other humanitarian professions. Honor might come slowly, but honors are not the chief thing, though I know of no more inviting or promising field where a man might hope to gain the world of greatest opportunity and at the same time save his own soul in unselfish service to his fellow men. It was to just such disinterested active participation in public life that one of our great presidents, the late Grover Cleveland, called his fellow citizens at a notable academic celebration several years ago. "Of the many excellent speeches at the two hundred and fiftieth anniversary of Harvard College," wrote the late Mandell Creighton to the London 'Times,' "none was of more general interest than that of President Cleveland, who, with great modesty, deplored his lack of university education, and exhorted men of learning to take a greater part in public affairs. 'Any disinclination,' he said,

'on the part of the most learned and cultured of our citizens to mingle in public affairs, and the consequent abandonment of political activity to those who have but little regard for the student and the scholar, are not favorable conditions under a government such as ours. And if they have existed to a damaging extent, recent events appear to indicate that the education and conservatism of the land are to be hereafter more plainly heard in the expression of the popular will.' "

Texans have not been slow in responding to calls to public service from State or Nation. Such calls they have not infrequently answered with conspicuous public service. But if Texas has sent publicists to Washington, bankers, college executives, and railway presidents to San Francisco, St. Louis, Chicago, and New York, Texas has hardly held her own with the rest of the country in science and scholarship, whose service is equally important to State and society. Nor in this respect has the South as a whole held her own, but for that matter the country itself is just beginning to hold its own in science and scholarship with the rest of the world, and there are better days ahead of Texas and the South. These better days will call for leisure as well as learning, for the philosopher as well as the promoter, for men of daring to think as well as men of courage to act, for men whose thoughts are their deeds, men who can exclaim with Hegel, "Das Denken ist auch Gottesdienst." The call to the vocation of scholar or scientist this address makes a thousand times, from its initial line to its final paragraph. Where it is not a call it is a charge or a challenge, and appeal follows on appeal where argument does not follow argument. A great wave of agitation and enthusiasm for vocational education has been passing over the entire country. We have felt the force of this wave, but on the top

of the wave the Rice Institute would place vocational education for science, for scholarship, for citizenship, training for the vocation of scientist, training for the vocation of scholar, training for the vocation of citizen. There is not a man in this company to-day who does not envy the inventive scholar his idealism, his intellectual freedom, his fearless pursuit of truth, his persistent devotion to the things of the spirit. Nor is there a man within earshot who does not envy the practical philosopher his resourceful, practical sense. In these reactions we have one of the larger ends of education, for one of the great ends of education as a social work in our time is on the one hand to glorify the workaday world with the idealism of the poet and painter, the preacher and professor, and on the other hand to humanize and inform the world of science and art and letters with the practical purpose and poise of the calculating captains of industry and commerce. Perhaps I may combine the two orders of ideas on which I have touched in no better way than by saying that learning in our day is no longer an affair of the cloister and the clinic alone; it is also of the mill, the market-place, and the machine-shop. In fact, a not unfamiliar conception of the university itself is that of a mill for converting the youth of the commonwealth into citizens of the State. Its function is to transform mind into a higher order of mind; the mind of the individual, the mind of the community, the mind of the State, the mind of the race, into a higher order of mind. Its business is to train efficient thinking men for the business of life. In reality, the earliest mediæval universities were professional and technical schools. It was largely as a professional school for the training of the minister and the schoolmaster that the early American college flourished. The original learned professions were theology, medicine, and law. We are adding engineering to this original list by

making its elemental doctrines the means of liberal culture as well as the groundwork for a profession which is fundamental to all industrial and commercial progress. Similarly we are adding architecture and education, and a little later agriculture. With us, men for these professions are to be scientifically equipped through special training based on a broad foundation of liberal education. And as regards this broad foundation of liberal education, our ideas of liberal and technical learning have been experiencing a transition from rather strict delimitation to bounds broader and broader. By liberal learning we no longer mean the so-called classical humanities alone, but also the new humanism constituted of modern civilization and modern culture, of modern letters and modern science. And by a foundation for technical training in applied science we now mean the great range of physical sciences which at one time could be subsumed under the term natural philosophy; the great range of active biological sciences which have developed from the ancient descriptive science of natural history; the great range of psychological and philosophical sciences which, under the influence of scientific method, have grown out of the older mental and moral philosophy; and finally, the larger range where men are still seeking science, in which the sciences of matter and of life and of mind are to be extended to the crowd, to the community, and to civilization itself as objects.

In the immediately preceding paragraphs of this section of my remarks I have spoken of the strength that the new university possesses in its freedom, in its faith, and in its faculties of science, humanity, and technology, as well as in the financial resources of its foundation. I have also pointed out several ways in which that strength is to issue in service to State and Church and society through science and schol-

arship and citizenship. In the several concluding paragraphs I desire to call attention to certain other sources of strength and support—sources of human strength that support the university—and to some aspects of the larger relations of a university's life.

Education does not begin with the university, nor does it end in the university. It is a matter of life, the whole span of life, and both before and after. The Church finds its continuance beyond the death of a man, and science has been teaching the State to look for its beginnings far in advance of the birth of the child. "Is it not strange," asks Thomas Traherne, "that a little child should be heir to the whole world?" To secure that heritage for the child, man's collective force and knowledge conspire, in a century "in which the care and love of children have taken their place as the first general solicitude of all civilized societies." Ours has been called the century of the child. No known age of the world's history before our own could have painted the picture of "the innumerable children all round the world trooping morning by morning to school, along the lanes of quiet villages, the streets of noisy cities, on sea-shore and lakeside, under the burning sun, and through the mists, in boats on canals, on horseback on the plains, in sledges on the snow, by hill and valley, through bush and stream, by lonely mountain path, singly, in pairs, in groups, in files, dressed in a thousand fashions, speaking a thousand tongues." This panorama of the world repeats itself in Texas. In the schools for the children of Texas and the South lie the deeper roots of this new university's life. The foundations on which we build are laid by these schools of the State and the Church. The upper limit of their work determines the lower limit of ours. On the religious side, the foundations are laid by the Sunday-schools and the private preparatory

schools maintained by the churches; on the secular side, by the public schools maintained out of public funds, and by private secondary schools which may or may not be independent of religious control. In America the separation of State and Church is sharp and distinct in matters of government; this separation is also sharp and distinct in matters of education. Religious teaching thus excluded from the public day-schools is being systematically and thoroughly promoted in the Sunday-schools of the churches. Through steady and marked improvement in their teachers, their methods, their equipment, their curriculum, their grading, and their results, these Sunday-schools are becoming entitled to rank as a part of our national system of education. As regards the schools for secular education in the older States of the South, we find that, largely because of strong individualistic tendencies in those States, the private preparatory school has flourished. The oldest State university in the South, namely, the University of Virginia, was until recently fed almost exclusively by private schools all over the South, manned by University of Virginia men. But the wave of public education, from its earliest springs of source in Massachusetts and Virginia, has spread over the whole South, until now from Virginia to Texas each State is building from the moneys of its public chest an educational highway for all its children from kindergarten to university. This wave, however, has not submerged completely the private schools. Many of these private foundations still survive through providing advantages of small classes, individual instruction, personal supervision, and personal contact in smaller academic communities—advantages which the public schools are not yet able to offer in the same degree. Nor is this wave of public education beating in vain upon the lowlands and the highlands of Texas, for any inquiry into public

education in Texas would show steady growth and improvement, from earnest beginnings, in at least four things: the laws concerning education; the subjects of instruction and programmes of study; the organization of the teaching, including training and supervision; and the administration of the laws and of the departments created under them. This is neither the time nor the place to go into details concerning public education in Texas, but a few further general observations may perhaps be made with propriety. When the history of public education in Texas comes to be written, the chapter recording the history of our own time will show that the people who are taking thought for education in Texas realize that for State as for private education deliberate organization is necessary, inspired by an adequate theory of education—a theory distilled from the accumulated history of education, a spirit of conscientious striving to deal with three questions: Why is education undertaken? What to teach so as to achieve the ends of education? How to teach so as to educate? That same chapter of history will show that if, with the inevitable hospitality of a new country where all things are open to experiment, there has been a somewhat too ready acceptance of novelties in education, there has also been deep moral earnestness with its abhorrence of semblances and shams, for with us a thorough desire to bring all current opinions—for example, the educational doctrines of such earnest enthusiasts as Mr. Edmond G. A. Holmes of London, Dr. Georg Kerschensteiner of Munich, and Dr. Maria Montessori of Rome—to the test of experience and judgment by results, has always been accompanied by a feeling of the moral duty of spreading knowledge, of popularizing the results of study and making them known to all. It will show increasing desire of our people for a good race and good government, for the city beautiful and the country

beautiful, for good conscience in matters of truth and good conscience in things of taste—a desire remaining without rest and unsatisfied until all the children of the State shall be in school all the time for nine months of every calendar year. That same chapter will also show quick response to the present popular movements for social centers and play grounds, and more general recognition of the right of every child to live and grow up to the full stature of a man, and the right of every man that labors to some leisure for his own spiritual growth. It will show a growing knowledge on our part that democratic education is of all forms the most costly, and a generous determination on the part of the people to meet the cost through taxation. And, finally, that chapter of history will also record a growing disposition on the part of the people of Texas to provide at the expense of the State all things necessary in the way of education—physical, mental, moral, elementary, secondary, university, scientific, literary, artistic, liberal, technical, or professional—without restriction of subject or kind or grade; without limit of amount or cost; without distinction of class or race or creed or sex or age. This means money, money, money, and men, men, men—the men to assume the responsibilities, the money to pay the bills for the provision of all these opportunities. And in particular, as regards the high schools on which this and other universities and professional schools must lean, is not the thing most necessary for the welfare of university education in Texas to secure at all costs good teachers and plenty of them for these schools? Indeed, if the strongest and finest minds are to be prepared for the universities, should not the staff of the public high school be composed of men and women of very extensive culture in several branches of learning and intensive specialization in some one field: a few members of erudition in scholar-

ship, a few of productive capacity in science, a great number of exceptional teaching ability? The prime obligation of this corps of teachers would be not to scholarship, nor to science, nor to study, nor to the school even, but to the students themselves: and to them not merely as mechanisms that can be taught to think, but to their whole selves as think-ing, feel-ing, will-ing beings. The tutors, not task-masters but fellow-workers; the students, not driven by discipline, but led by enthusiasm; the school, not an interruption in the normal life of the student, but the surest means to its complete realization. In a word, the school would be centered on the students. Their studies and their sports, their work and their play, would be so ordered as to feed and fire their enthusiasms, to stimulate and strengthen intellect in exact thinking and imagination in clear vision, to arouse to action their latent powers of mental acquisitiveness, to develop initiative and again initiative, to enable them to discover themselves and their relations to the great arena of service and opportunity, to train them for the duties of intelligent citizenship in the republic and fit them also to enjoy and perhaps later to advance the larger world of civilization in letters, science, and art.

Another source of unfailing strength to the new university exists ready to hand in the presence of the several hundred college men and women now resident in the city of Houston. While the coming of the new institution and contact with its life will serve to warm their loyalty to their own respective colleges, because of that very interest and devotion they will be quick to interpret sympathetically the aims and ideals of the Rice Institute to the people of its community. They will thus become one of the first of its human assets and one of the foremost of its living sources of strength. To renew and freshen the academic interests of these former colle-

gians, to stimulate and sustain the intellectual life of the teachers of the city's schools, to tempt business and professional workers to at least occasional excursions into the academic atmosphere surrounding the university, to keep all the members of the Institute in a lively and appreciative sense of familiarity with fields of learning and investigation other than their own, to bring all the people of the city and community into more intimate touch with the academic life of the university, and to carry the influence of that life directly to many homes not represented on the rolls of its undergraduate or postgraduate students, regular series of public lectures, in the form of university extension lectures, will be offered without matriculation fee or other form of admission requirement. These performances are to be authoritative in character, but as non-technical and popular in treatment as their subjects will permit. From domains of literature, history, science, art, philosophy, and politics subjects will be chosen of current interest as well as those of assured and permanent value.[1]

These various sources of strength and support which I have catalogued can hardly be measured quantitatively nor can they with any ease be arranged in series of greater or less, but I have no fear of exaggerating when I say that no

[1]The present plan for university extension lectures at the Institute consists in giving each academic year two regular series of thirty-six lectures each, the first series running through three divisions of twelve lectures each on Mondays, Wednesdays, and Fridays, from the middle of November to the middle of February, and the second series running similarly from the middle of February to the middle of May. All these lectures are delivered in the lecture halls and amphitheaters of the Institute, each afternoon lecture beginning promptly at 4:30 and closing not later than 5:30. In addition to the afternoon lectures occasional Thursday evening lectures are being given. The plan has met with hearty response on the part of the people of Houston, the attendance on the lectures having ranged from some thirty to more than five hundred auditors at a single lecture. By the end of the present academic year (1914–15) an aggregate of rather more than twenty courses of from three to twenty-four lectures each will have been delivered by Messrs. Axson, Blayney, Caldwell, Dumble, Evans, Glascock, Guérard, Hitch, Hughes, Reinke, Tsanoff, Van Sicklen, Watkin, Weber, and Wilson.

source of strength to the new university will be more permanent in its influence than that of the aspirations of the people themselves for their children; for, from the captain of industry on down to the most modest member of the firm, whether any or all had the advantages of a formal education, all are determined that their children shall have such advantages. And in this determination lies the basis for confident expectation that within a very few years there will be no family of five members in the city of Houston that will not have had one or more representatives on the rolls of the Institute. Furthermore, the time is not far distant when our citizens shall be coming to think of the city's university when writing their wills, and soon in Houston, as in Cambridge and Chicago and San Francisco, a man will leave a stain on his family history if he fail to remember the city's university in his last will and testament.[1] Moreover, the endowing of scholarships and fellowships, the founding of memorial lectureships and professorships, the erecting and endowing

[1] The day of public benefactions by Houston philanthropists has dawned, though still in its earliest morning. The late Mr. George H. Hermann, who shortly before his death handed Mayor Campbell a deed conveying to the city a tract of nearly three hundred acres of land lying just across the road from the Rice Institute, to be used perpetually for the purposes of a public park, has by his will given also to the city a site for a Charity Hospital, together with holdings that will yield an estimated endowment of three million dollars for the latter institution. With engaging frankness Mr. Hermann told me that he had been influenced in making this disposition of his property by the example of William Marsh Rice and the plans of the trustees of the Institute. Thus, in addition to a university for all the people, this city of homes and schools and churches is to have a great public park and a great public hospital. While the city's list of public institutions provided by private donation has been steadily growing, the city has not been waiting indifferently until such provision should have met all its needs. As a matter of very recent history the city itself built during the mayoralty of Mr. H. Baldwin Rice a magnificent municipal auditorium. It was in this auditorium that on the occasion of the formal opening of the Rice Institute there assembled, under the eloquent dedicatory sermon of the Reverend Dr. Charles Frederic Aked and an inspiring service of song and prayer led by the Reverend Dr. Henry van Dyke, an audience of some six thousand souls, including the clergymen and choirs of practically all the churches of the city, "solemnly to link themselves with joy and deep thanksgiving to the consecrating acts by which the new university was publicly dedicated to the high purpose set forth in the Founder's will."

of name-bearing buildings, the equipping of scientific expeditions, the maintaining of university publications, and a score of other ways opened up by the growth of this institution, will offer both to young and to old many avenues for making and perpetuating family history.

In the history of the public welfare in Texas many organized movements, local, State, and national, for educating public opinion, for elevating public morals, for inspiring public taste, for improving public health, have by their propaganda been assisting in preparing the way for a new university in Texas. Of such organizations Houston has a long and active list whose members are determined that their city shall be great and good and beautiful: an art league, a Carnegie library, a chamber of commerce, a Chautauqua circle, lecture and lyceum bureaus, a number of musical societies, a settlement association, a social service federation, a symphony orchestra, and several women's literary and political clubs and unions. In all their constructive undertakings these organizations have at all times enjoyed generous and hearty support on the part of the several local newspapers, which are maintaining the better traditions of American public prints in instantaneous seeking and supplying of information, in eternal vigilance of editorial comment and criticism, in wireless response to the social feeling and sympathy of the community, in the education of public opinion and the reflection of the public mind. With all these local associations the university would seek to co-operate, in no way would it compete with them, in all possible ways it would seek to avoid all unnecessary duplication of their work. Furthermore, we enter also into the results of years of labor for the common welfare which the people of Texas have been receiving at the hands of many voluntary State associations dedicated to the public service. Among the latter

there stand out prominently the Conference for Education in Texas, the State Federation of Women's Clubs in Texas, the State Teachers' Association, the Texas Welfare Commission, and the various patriotic associations for perpetuating relationships with the American Revolution, the Republic of Texas, the War between the States, and other periods of State and national history. These women—for the majority of such workers in Texas are women—have been showing enthusiasm, originality, statesmanship in their work; they have also been showing that these qualities are not the only ones which make men and women leaders when a new country is to be settled in the faith and fear of the Lord, for they have been showing that there is also potent and efficient force in gentleness, quietness, and confidence. These workers make their appeal to the university from the intellectual quite as much as from the moral side. The case for their propaganda may be set in famous words of Cromwell: "What liberty and prosperity depend upon are the souls of men and the spirits—which are the men. The mind is the man." And similarly, in a good passage from Mrs. Bosanquet's book, "The Strength of a People," which I should like to quote: "In all considerations of social work and social problems there is one main thing which it is important to remember—that the mind is the man. If we are clear about this great fact, we have an unfailing test to apply to any scheme of social reformation. Does it appeal to men's minds? Not merely to their momentary needs or appetites, or fancies, but to the higher powers of affection, thought, and reasonable action." Ever zealous to understand the aspirations of the popular will, ever zealous to help the people in their quest for enlightenment, ever zealous to lead the people to things above themselves, this university would, in the spirit of a passage from Spinoza, take its "best pains not

to laugh at the actions of mankind, not to groan over them, not to be angry with them, but to understand them." Testing any programme for better uses of life and leisure by a double criterion: Is it based on an understanding of the ways of men and the needs of humankind? and Does it appeal to the understandings of men? the university would seek, while preserving its own freedom and independence, to assist in the advancement of humanitarian movements in State or Nation or world. This humanitarian aspect of university service, as differentiated from the more strictly scholastic and scientific activities of university life, appearing under newer forms comparatively recently in the so-called university settlements and in the university extension movement, finds its latest phase in co-operative unions for world-wide programmes of scientific investigation on the one hand, and on the other, in the organized movements for improvement of good will and the promotion of peace among the nations. In such united efforts the new institution would participate, for if the university, though on private foundation, is in its first days what Bryce calls a municipal university, Haldane a civic university, Dabney an urban university, in its future days it is to be more than a university of Houston—it is to be a university of Texas, a university of the South, and later, let us hope, in reality as in aspiration, one among the national institutions, reflecting the national mind, one among the universities of the nations, fostering the international mind and spirit in cosmopolitan ways such as the mediæval universities enjoyed before the death of universal language and the divisions in a universal Church.

IX

THE UNIVERSITY: ITS SPIRIT AND SUMMONS

IN thus endeavoring to write about the meaning of the new institution I have at some length written about its sources in the founder's philanthropy and its history in the public spirit of his friends; of its site, glorious in problems bristling with difficulties and joyous in possibilities of creative effort; of its scope in entering upon a university programme for the advancement of letters, science, and art, by investigation and by instruction, in the individual and in the race of all human kind; of its saints of the past and its seers of the present, pointing by exhortation and example to the highroad along which progress in these high purposes lies; of the shades and towers in which are to be undertaken the daring adventures of its life in deeds of thought and action; of its staff of professors, lecturers, and instructors, in whose personality and work of research and teaching are to be found combined the careers of citizen, scientist, scholar, and schoolmaster; of its students, through whose studies and standards in scholarship and sport constant contributions are to be made to the character, culture, and citizenship of the Republic; of its strength in its freedom from political and ecclesiastical affiliations, in its faith in the progress of the human spirit, in its faculties of science, humanity, and technology, in its self-governed student democracy, in a definite educational policy, and the driving power of ideas and ideals backed by material resources for their realization; of its support in the schools of the city, the county, and the commonwealth, in the college men and women of the community, in the captains of indus-

try and commerce, in all organized conferences for education, welfare, and uplift, in the resolute determination of the people who have been winning the West, now to win the best for the sons and daughters of the West. My further and final object is an attempted portrayal of the spirit which presides over the university; a presentation, more or less rough, of that breath and finer form of the spirit of learning which lends what is perhaps its chief glory to the life of reflection and gives what may be perhaps its final purpose to the life of action.[1]

Twenty years ago it was specialization. Ten years ago it was specialization. To-day it is specialization still, whether in academic education or in professional training, but specialization on the broadest kind of general foundation. Preparatory to attacking the practical problems of the material world, men are coming to provide themselves with the most complete theoretical training yet devised in the world of mind. On the other hand, pure scientists are continually on the outlook for applications of their discoveries either to the ideal world in which they live or to the real world in which they find their livelihood. As a result the professor's desk is nearer the market-place, closer to the counting-house, within easier call of State and Church than ever before. The university is saying to its men of letters, "You must be leaders of men"; to its men of science, "You must be also men of affairs." The world in its turn is demanding that its engineers be cultivated men, and that its skilled artisans be skilled in the liberal arts as well.

Where theory and practice thus meet there must be rea-

[1] To bring within the time limits of the programme the reading of an address obviously too long to be read in its complete form in public on any occasion, only four sections of this address were actually delivered as a part of the formal exercises of the inauguration and dedication of the Rice Institute, and under the caption, "The Meaning of the New University: Its Source, Its Site, Its Scope, Its Spirit."

son, and this reason is restoring to learning its unity, in whose spirit we read the strength and the vision of the university. This spirit appears to us under three aspects in those disciplines by which men seek for truth and strive after beauty in letters, in science, in art. Art was originally the handmaid of religion; science, at one time the servant of philosophy, has more lately become its master; letters, in the beginning the playfellow of poets and story-tellers, has grown to be humanity's recording angel. Science has its source in a sense of wonder, art in a sensitiveness to measure and proportion, while literature partakes of the substance of science and the form of art. Science consecrated to the conquest of truth would solve the universe; art would recreate it in the conservation of taste. Science progresses by inquiry, art under inspiration. Intuition dominates the artistic reason, while inference controls the scientific.

In other words, by the spirit of liberal and technical learning I understand that immortal spirit of inquiry or inspiration which has been clearing the pathway of mankind to intellectual and spiritual liberty, to the recognition of law and charm in nature, to the fearless pursuit of truth and the ceaseless worship of beauty. Its history is the history of the progress of the human spirit. Led by an instinct for knowledge, an instinct for harmony, an instinct for law, that spirit has brought the twentieth century its most precious possessions: the love of reason, the love of art, the love of freedom.

There abide these three: the spirit of science, the spirit of letters, the spirit of art, but the man has not arisen to say to us which is the greatest of the three. These are the faces of the spirit of learning, above which there hovers a halo called by the modern philosopher the spirit of service, and by the ancient seer the spirit of wisdom. Knowledge becomes

power only when it is vitalized by reason; it becomes learning only when it lives in the personality of a man; it becomes wisdom on translation into human conduct. I know as well as you that the spirits of which I speak are ghosts who will themselves not speak until they have drunk blood. We propose to give them the blood of our hearts in the service of the new institution.[1]

Ladies and Gentlemen of Houston: At your gates there have arisen for all time the walls and towers and men of the Rice Institute, whose life is to be an integral part of your life, whose service is to be local in the best sense, whose significance, let us hope, may be State-wide, and even national, in its reach, on a foundation builded for Houston, for Texas, the South, and the Nation. A long avenue doubly lined with trees, at one end the captains of industry and commerce in factory and counting-house, at the other a college community in academic shades dedicated to liberal and technical learning, the happy homes of Houston lying in between! A university devoted to the advancement of literature, science, and art; to the promotion of letters as the record of the achievements of the human spirit; to the promotion of science as the revealer of the laws and the conqueror of the forces of nature; to the promotion of art as the sunshine and gilding of life. A society of scholars in whose company your children, and your children's children and their children, may spend formative years of their aspiring youth under the cultivating influences of humane letters and pure science, pursuing culture with forward-looking minds and far-seeing spirit before undertaking in the Institute's professional schools special or technical training for the more sober business of life. A temple of wisdom and sanctuary

[1] It is to Professor von Wilamowitz-Moellendorff, I believe, that I owe this figure of speech.

of learning within whose courts and cloisters you yourselves may find an occasional retreat in which to think more quietly and more deeply; perhaps to worship more devoutly and more intelligently; certainly to contemplate the deeper things of patriotism and politics, of reverence and religion, of peace and progress; and mayhap to discover, if never before, that you may belong to the great community through which the Eternal has worked for ages, that you may have a share in the high privileges and solemn duties which belong to every member of that great community, that in the continuity of human history you may march forward, if you will, in a great pageant that moves from the living past through the living present into the living future.

Not long ago I stood on a great rock—a great living rock —within eyeshot of the birthplace of modern civilization. Upon it rose those incomparable ruins, mighty as the mind that conceived them, majestic as the mountains and sea that call to them. In their midst the gods of the Greeks still live. And of all those gods it was to her who typifies science that the Parthenon was dedicated; to that great goddess who sprang full-armed from the head of Zeus at the touch of fire and toil, to conquer the deep himself.[1] It is no long flight of fancy from the Parthenon above the fields of Hellas to these towers that rise on the plains of Texas. Under her ancient promise, may Pallas Athena preside over these academic groves and guide men by the spirit of science and the spirit of art and the spirit of service in their search for the great, and the lovely, and the new, for solutions of the universe in terms of the good, the beautiful, and the true!

And I recalled the words of the wise man of another chosen people:

[1] The idea and experience of the first part of this paragraph I am obliged to share with Professor Sir Ronald Ross, but I am unable to supply the appropriate citation.

"Except the Lord doth build the house, they labor in vain that build it."

"I prayed, and understanding was given me; I called upon God, and the spirit of wisdom came unto me; I preferred her above sceptres and thrones, for she is unto men a treasure that never faileth."

"For wisdom is a breath of the power of God, and a pure effluence flowing from the glory of the Almighty. She is the reflection of the everlasting light, the unspotted mirror of the power of God and the image of his goodness. And in all ages, entering into holy souls, she maketh them friends of God, and prophets."

Wisdom hath builded her house,
She hath hewn out her seven pillars;
She hath mingled her wine;
She hath also furnished her table,
She hath sent forth her maidens; she crieth
Upon the highest places of the city,

"Whoso is simple, let him turn in hither";
As for him that is void of understanding, she saith to him,
"Come, eat ye of my bread,
And drink of the wine which I have mingled,
And walk in the way of understanding.

"Blessed is the man that heareth me,
Watching daily at my gates,
Waiting at the posts of my doors;
For whoso findeth me findeth life,
And shall obtain favor of the Lord." [1]

EDGAR ODELL LOVETT.

[1] These several passages, from the Book of Proverbs and the Book of Wisdom, in slightly abbreviated form have been distributed in the carving on the caps of the columns which support the arches in the cloisters of the North Wing of the first Residential Hall for men.

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THE SEVERAL PIECES APPEARING IN THIS PAMPHLET ARE REPRINTED FROM A COMMEMORATIVE VOLUME INSCRIBED BY SPECIAL PERMISSION TO THE HONORABLE WOODROW WILSON, PH.D., LITT.D., LL.D., MAN OF LETTERS, LEADER OF MEN, THIRTEENTH PRESIDENT OF PRINCETON UNIVERSITY, TWENTY-EIGHTH PRESIDENT OF THE UNITED STATES, AND WHICH CONTAINS AN ACCOUNT OF AN ACADEMIC FESTIVAL HELD IN CELEBRATION OF THE FORMAL OPENING OF THE RICE INSTITUTE

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CONTENTS

HENRI POINCARÉ[1]

AMONG the various ways of conceiving man's affection for life there is one which perhaps Metchnikoff has not heretofore investigated, yet in this one way that desire has a majestic aspect. It is quite different from the way one usually regards the feeling of fear of death. There come moments when the mind of a scientist engenders new ideas. He sees their fruitfulness and utility, but he knows that they are still so vague that he must go through a long process of analysis to develop them before the public shall be able to understand and appreciate them at their just value. If he believes then that death may suddenly annihilate this whole world of great thoughts, and that perhaps ages may go by before another genius discovers them, we can understand that a sudden desire to live must seize him, and the joy of his work must be confounded with the fear of having to stop it forever.

We can imagine Abel's anguish at the thought of approaching death, when none about him could understand the ideas which he wished to propagate, and which he feared forever lost. We appreciate the moments that Galois must have experienced before fighting his duel, if we remember that a few hours before going on to the ground from which he should not return, he had not written a single line of his great discoveries.

Poincaré died at the most brilliant moment of his career, in full vigor. His spirit was young; original ideas were

[1] A lecture delivered at the inauguration of the Rice Institute, by Senator Vito Volterra, Professor of Mathematical Physics and Celestial Mechanics in the University of Rome. Translated from the French by Professor Griffith Conrad Evans of the Rice Institute.

vibrating in his brain. Did he realize that the world that filled his mind might crumble at any instant, like the wonderful castle of Walhalla, overrun with sudden fire? We cannot say. I hope, for the peace of his last hours, that he did not see death approaching; and yet the pages of his last memoir contain a sad presentiment.

His mind now is resting, and perhaps the present hours are his first hours of repose. In consideration of the activity which he displayed, the number of different questions which he treated, the new conceptions of science which he quickly absorbed, the number of original ideas which he disseminated, we are sure that he could not have rested a moment during his life. Poincaré was ever at the breach, a good soldier, until his death. During these last thirty years there has been no new question, connected even remotely with mathematics, which he did not subject to his deep and delicate analysis, and enrich with some discovery or fruitful point of view.

I believe that no scientist so much as he lived in constant and intimate relation with the scientific world that surrounded him. He received ideas and gave them by a process of exchange both rapid and intense, which ceased only on the day when his heart ceased to beat. That is why, if we were to characterize the recent period of the history of mathematics by a single name, we should all give that of Poincaré, for he has been without doubt the most widely known and celebrated mathematician of recent years. Little by little he created a type of scientist and philosopher. Without being aware of it, the mathematicians of his time, by means of subtle sympathies and bonds, grew necessarily into that type.

Scientific development, the relations of science with life, and of the general public with the scientist have been greatly

changed in these late years. The causes are easy to understand, the effects striking. Brilliant discoveries have illumined every department of life. It is for this reason that science in general has become popular, and people expect from the mathematical and physical sciences particularly, results always new and ever more useful. It may be that people even have come to have a confidence in them which surpasses their power. The scientist who a few years ago stayed hidden in his study or in his laboratory to-day mingles with other scientists and with the public. He hears the questions which are asked from every side, and he must reply. Too much urged, he must sometimes reply before his thought is ripe.

Congresses and scientific reunions have increased in number; and popular presentations and learned lectures, where people wish to know the last word of science, follow each other without pause. There is no longer any time to wait. Modern life, eager and tumultuous, has invaded the quiet dwellings of the scientists. Some centuries ago people published great volumes; they were the synthesis of the thought of a man's whole life. But that was not sufficient for the scientific development now in progress. Scientific journals to-day ask for memoirs, in which work is published as it progresses. The proceedings of the academies, short and precise reviews, have appeared. A man reports in a few words every discovery as soon as he has made it. Time presses; one fears that the next minute the discovery may be lost. But the communications of the congresses, which no one has the leisure to revise, exceed in rapidity even the proceedings of the academies and of the scientific societies. We wish to know what has not been done. We say what we hope to find. We confide that which we shall never have courage to print. This development has created a particular state

of mind among scientists, and has changed their lives, their ways of working, and even of thinking.

There are great advantages in this modern scientific life as I have just presented it. Research has become almost collective. The energies of the investigators are summed; their discoveries follow each other rapidly; competition spurs them on. Their number increases from day to day. But how many objections we can oppose to these advantages! What refinement of detail is lost! Perhaps that patience, which for Buffon was genius itself, has vanished in the tumult of the present hour. Poincaré was a modern scientist in the full meaning of the word. There was no congress, no scientific reunion where his word was not heard. Most of the scientific journals received his memoirs and the accounts of his investigations. The universities of Europe and America have heard his conferences and lectures.

A work so absorbing, so intense, may easily overdrive to the point of danger a weak or sickly constitution. Is it this excess which fatally has led Poincaré to the tomb?

Calm and serene scientific work is often a rest for the mind. The pleasure of the new results that one finds suddenly, like a beautiful landscape at the turn of a mountain road, alternates with the labor of research. The difficulties of analyzing the question are often generously compensated by the solutions which appear at the precise moment when one expects them least, by means of methods which one could not hope to find useful. The work which Euler, Lagrange, Gauss knew may be compared to a pleasure voyage in the finest of countries; but that which public lectures and conferences demand, which journals ask for at a fixed rate, very often fatigues and irritates like a long and rapid tour, during which one has no time to consider the surrounding beauties and charms.

I imagine that a mind even so largely endowed as that of Poincaré, one that possessed all the gifts appropriate to scientist and author, must have felt fatigue and weariness before a mass of labor which year after year continued without intermission or rest, and every day became more demanding and intense. But modern life called for it, and a famous man like Poincaré, most popular of mathematicians and philosophers, could not refuse.

Perhaps he felt that it was the duty of his genius towards humanity to spread abroad his ideas, not hiding any. He gave as he found, generously, as a great lord who has immense resources and is sure that no hasty expenditure can use them up. He did not hesitate between the desire to make known his thought to a great public and the fear of giving out results not yet completely ripened. An unusual lucidity saved him from mistakes. He always laid bare his ideas, and he did not hide his methods. That ingenious and subtle way of giving results and concealing the manner of getting them, so dear to the ancients and always so tempting, never appealed to him. He never waited to make complete and final his discovery, and give it a systematic and definitive form; although it is exceedingly self-satisfying to stop and investigate from every side that which one has discovered and which is really one's own. It is indeed pleasant to find new aspects of it, and obtain its applications.

But Poincaré resisted all these temptations. He sacrificed these gratifications of the scientist to a high ideal. He went ever ahead. New questions awaited him, and the time for considering the details of the old never came. Indeed, I believe that he consistently avoided details and did not wish to give his time to minute questions. It was not his business either to correct or to revise that which he had done. The whole was everything for him, the details nothing.

This inherent ardor gave to his nervous style a personal stamp and character. Perhaps it is for this reason also that it is impossible to compare Poincaré and other investigators, even those of the present date. He is too modern for any comparison to be possible. Among scientists he is like an impressionist among artists, and I know of no other scientific impressionists among the great men of the past.

It is quite certain that no theory like universal gravitation or electrodynamics will be attached to his name, as to those of Newton, Ampère and Maxwell. Among the great number of methods which he invented and developed from day to day are there any comparable with those which made famous Archimedes or Lagrange? It would take a great deal of time to distinguish everything that there is in his works, in order to say which of the seeds that he has sown will sprout, and which finally will be most fruitful. But if we ask to-day, on the morrow of his death, at what level we should place his genius, we must reply that he has reached the altitudes where dwell the great of human kind. There is certainly a philosophy that is Poincaré's, and an analysis, a mathematical physics and a mechanics that are Poincaré's, which science can never forget.

His renown during his life was great. Few scientists and a very few mathematicians have had celebrity equal to his. A physicist would find the reason for this in what I have just been saying, remarking that his spirit and the spirit of his time vibrated in unison, and that he was in phase with the universal vibration. Some great scientists have labored, urged by an internal force, without hearing or concerning themselves with those about them. They have been misunderstood. The pitch of their voices was not in harmony with that of their times, and they uttered tones which resounded only in later generations.

Nothing is harder than to prophesy the reputation of a scientist. History has given too many contradictions to obvious prophecies. Will not what one wonders at to-day be unessential to-morrow? But it is impossible that Poincaré's voice shall not be heard in future times. The questions that he treated are so important and fundamental that a great number of investigations will follow those which he commenced. His works will be studied in detail, and by many. They will form a very precious mine for all the scientists to come. The wealth of it, even at the present moment, we can surmise.

These last few words explain what I am going to talk about. It is impossible to summarize surely and adequately the entire work of Poincaré, and to give a complete survey of his mind and his wonderful activity. But I wish to devote to him this lecture. His voice should have sounded here in this solemn event, and the Rice Institute should have been inaugurated also under the auspices of his illustrious name. I shall endeavor to recall, then, a very small number of his discoveries, by trying to trace their principal characters, and to show their place in reference to the time when they were developed.

I hope to be excused if I recall facts already known, and if I consider a few details that are elementary. But since I cannot be complete I must be clear, and I shall therefore aim not to describe matters in a difficult manner. I hope that you will understand my selections from his works: I have endeavored to take them from various branches of mathematics in order to show the development of several of his speculations.

I begin with the one of Poincaré's investigations that first brought him to the attention of the mathematical world, and at once showed his great talent in analysis. This is the

theory of linear differential equations and of Fuchsian functions.

The theory of functions was the most important conquest of analysis during the last century. I did not hesitate at the Congress of Mathematicians at Paris to call the nineteenth century the century of the theory of functions, as the eighteenth might have been called that of infinitesimal calculus. An intuitive idea, like the idea of function which everybody possesses, and which is related to the most elementary conceptions of quantities which vary with constant laws, gradually has invaded the whole subject of mathematics. Analytic geometry and the infinitesimal calculus gave it a start; algebra gave a great impulse to its systematic study; and Lagrange was able to write the first theory of analytic functions, the celebrated work in which are found the germs of later progress. It is only by the enlargement of the field of variables that the theory has been built up in a precise manner. It was necessary to consider imaginary and complex values in order to be able to explain the most hidden and most important properties of functions. To study a function without considering its imaginary and complex values would in many cases be like wishing to know a book by looking at what is written on the back, without reading the pages that are inside.

Cauchy, Riemann and Weierstrass have assisted us most in the reading of this mysterious book. All of their genius was necessary to lay bare to us its most interesting secrets.

But, as often happens, a general theory can be developed only by means of a profound study of a particular class of the objects which one is considering. Always some guide is necessary to provide orientation in a new region which has not yet been explored. The guide in the theory of func-

tions has been the detailed study of elliptic functions. A great many questions of algebra, of mechanics, of geometry, and of physics lead to the development of this branch of analysis, which has followed so closely that of the trigonometric functions: the elementary functions which Euler had already shown to be related to the logarithms and exponentials.

The history of elliptic functions is well known. It has been written many times, because it is perhaps the most interesting part of the history of mathematics. We pass from surprise to surprise in passing from one step, which we believe to be the most important of its development, to another, which brings forth new discoveries and new surprises. It has happened that the general theory of functions as well as all the other particular branches which are related to it has been cast upon the model of the theory of elliptic functions, and thus it is that the theory of Fuchsian functions, which represents the latest of these constructions, follows it also, in its essential features, according to the plan of Poincaré.

As is well known, the principles upon which the theory of elliptic functions is constructed are three: the theorem of addition, the principle of inversion and that of double periodicity. Everybody has learned in the elements of trigonometry that the sine and cosine of a sum of two arcs can be calculated from the sines and cosines of the arcs themselves, by means of very simple algebraic formulæ. In its specific form the theorem of addition of elliptic functions is quite similar to that which we have spoken of. It is not, however, under this aspect that it first appeared. Fagnano, an Italian investigator who made part of no scientific circle but possessed great talent, recognized it in the geometric properties of a special curve—the lemniscate of Bernoulli.

The genius of Euler was necessary to show the true nature of this property and to develop it in all its generality.

Another most subtle property, made evident only much later, is that of double periodicity. The periodicity of trigonometric functions comes immediately from their very definition. The double periodicity of elliptic functions was not discovered until Abel and Jacobi established the principle of inversion—that is to say, when they had taken the whole theory from the reverse side. Legendre, who thought the theory already complete, had to learn that he had not yet investigated its most fundamental conceptions.

Abel and Jacobi kept on in the route which they had struck out. The general theory of the integrals of algebraic functions was systematically constructed upon the theorem of Abel, which is an extension of the theorem of addition, upon the principle of inversion which Jacobi demonstrated for the first time in complete generality, upon multiple periodicity, and finally, upon the use of certain functions which are called Jacobian functions.

The principle of inversion under a new form, the extension of the idea of periodicity, and a modified type of Jacobian function were carried over at one stroke by Poincaré into the new domain—that of linear differential equations. It was that which constituted his work of analysis upon Fuchsian functions.

After quadratures, the great problem of infinitesimal calculus is the integration of differential equations. The most simple differential equations are the linear ones. We get an equation of this sort if we imagine a relation of the first degree to hold between the displacement of a particle, its velocity, and its acceleration, the coefficients of the equation depending in an arbitrary manner upon the time. The particular equation that we have just defined is of the second

order, because the velocity is the first derivative, and the acceleration is the second derivative, of the displacement; but we can imagine linear equations where derivatives appear of any order, and which are accordingly of higher order than the second.

Lagrange and many other mathematicians studied these equations, but Gauss investigated a special class of them completely. He connected them to their series, which was the hypergeometric series. Riemann went still further into these questions. He published a celebrated paper upon the subject; and after his death results of the greatest importance were found among his manuscripts. It seems that Weierstrass, without having published anything, had also discovered much relating thereto. But we owe to Fuchs an article, appearing in 1886, which called the attention of the entire scientific world to the new manner of considering linear differential equations. If we wish to form an idea of the new level to which Fuchs and his predecessors had carried the question, we have only to compare it with the theory of elliptic functions at the time of Legendre—that is to say, before Abel and Jacobi appeared upon the scene.

And yet advances had already been made into the new subject about to be developed, since the theory of the modular function was known.

The integrals of uniform functions are reproduced with the exception of an additive constant when the variable performs a closed circuit round singular points. This property is the origin of the periodicity of elliptic functions. In the same way, the set of fundamental integrals of a linear equation with uniform coefficients is subjected to a linear transformation on going around a singular point. We seek in this remarkable fact the key to the properties of those functions which can be obtained from the linear differential equa-

tions, by a procedure analogous to that of the inversion of elliptic integrals.

If the equation is of the second order, the ratio of two fundamental integrals undergoes a linear substitution on performing a closed circuit round a singularity.

We see then that the independent variable regarded as a function of the ratio of the two integrals must remain invariant of certain linear substitutions executed upon this ratio. The property which was to replace that of periodicity was thus found, and at the same time the principle of inversion. Poincaré started from this fundamental idea and interpreted geometrically that which we have just called a linear substitution. He started a systematic study of those substitutions which belong to a single discontinuous group, because it is evident that uniform functions which remain invariant of continuous groups cannot be other than constants.

Linear substitutions correspond geometrically to transformations of the plane by means of inversions by reciprocal radii, united with reflections. They play a very important part in non-Euclidean geometry, as several geometers, among others Beltrami, had already shown. Poincaré distinguishes two kinds of groups, those which he calls the Kleinian groups, which are the most general discontinuous groups, and the Fuchsian groups. These last, interpreted geometrically, leave the real axis fixed; but by composition with a certain new substitution they leave a circle invariant. It is this circle which Poincaré calls the fundamental circle.

The finding of all these discontinuous groups is in this manner reduced to the consideration of the possible regular divisions of the plane and of space. Poincaré distinguished between Fuchsian substitutions of different families, and obtained the corresponding groups. He then had actually to construct the functions which remained invariant of the

substitutions of these groups. These are the so-called Fuchsian functions.

Jacobi, starting from elliptic functions, had arrived at a function which he called Θ—that is to say, the Jacobian function. It is not periodic, but possesses what is called periodicity of the third kind, because increasing the variable by one period reproduces the function, multiplied by certain exponentials. Jacobi showed that the simplest way to obtain the theory of elliptic functions was first to define directly this function Θ by means of a series, finding its properties by algebraic methods, and then afterwards to calculate the doubly periodic functions as ratios formed by the Θ functions.

Poincaré followed a similar method for the Fuchsian functions. He started by calculating the Fuchsian Θ functions by means of series, and then found the changes that they underwent by performing upon the variable the linear substitutions of a Fuchsian group. Certain ratios formed by these Fuchsian Θ's remain unchanged when the variable is subjected to substitutions of the same group.

It is thus that the new transcendental functions were invented. By their introduction into mathematics a new field of analysis was created. We shall not enter into the details of the properties of these new functions, upon their connection with algebraic functions, or with Abelian or other transcendental functions. Neither shall we speak of a large number of questions of arithmetic, algebra and analysis which are related to them.

But we must say a word about the relation of the Fuchsian functions with the integrals of linear differential equations that have algebraic coefficients. The direction here taken by Poincaré is similar to the one which we follow when we express Abelian integrals by means of the generalized Θ

functions of Jacobi—that is, by means of the Abelian Θ's. Following this method, Poincaré introduced the Fuchsian Zeta functions, deriving them from the Fuchsian Θ. These are transcendental functions that express the desired integrals.

It has been asked several times, Have the Fuchsian functions applications? But one can answer with the question: What does it mean for a theory to have applications? Does the touchstone of a theory consist in its use in mechanics or physics? Did the theory of conics which the Greeks raised to such a high state of perfection take its honorable place in geometry only upon the day when people believed that those curves were the orbits of planets? Was it not already a great artistic monument, without reference to any practical application?

But we must not spend time upon these matters outside of our subject. Let us now abandon analysis and pass along to other questions.

There are two kinds of mathematical physics. Through ancient habit we regard them as belonging to a single branch and generally teach them in the same courses, but their natures are quite different. In most cases the people who are greatly interested in one despise somewhat the other. The first kind consists in a difficult and subtle analysis connected with physical questions. Its scope is to solve in a complete and exact manner the problems which it presents to us. It endeavors also to demonstrate by rigorous methods statements which are fundamental from mathematical and logical points of view.

I believe I do not err when I say that many physicists look upon this mathematical flora as a collection of parasitic plants grown to the great tree of natural philosophy. But perhaps this disdain is not justified. In the evolution of

mathematical physics these researches probably are to play ever an increasing part.

Explain to a child the first propositions of Euclid. It is not the geometric properties which surprise him; rather, that it is necessary to prove them, because his mind is not experienced enough to doubt their obviousness. In the same way, certain theorems which are demonstrated in mathematical physics produce upon some people a similar surprise.

We are not familiar with the development of geometry before Euclid, and we see therefore the complete work. It is quite probable that in the progress of geometry there were periods when feelings similar to those of which we have just been speaking existed, and little by little passed away.

The other kind of mathematical physics has a less analytical character, but forms a subject inseparable from any consideration of phenomena. We could expect no progress in their study without the aid which this brings them. Could any one imagine the electromagnetic theory of light, the experiments of Hertz and wireless telegraphy, without the mathematical analysis of Maxwell, which was responsible for their birth?

Poincaré led in both kinds of mathematical physics. He was an extraordinary analyst, but had also the mind of a physicist. We shall seek for the proof of this among his works.

The memoir that appeared in 1894 in the "Rendiconti di Palermo" is one of his most interesting papers. It bears the title, "On the Equations of Mathematical Physics." The author presents the question which he is about to treat in a short introduction, where he recalls the work of some of those who preceded him. But the question has a long history of which I shall speak somewhat.

Let me begin by saying that the work has a character

which is essentially analytic, and that it belongs to the mathematical physics of the first kind. In precisely what then consists the interest of this question, which so many mathematicians have investigated? No physicist would doubt, for example, that an elastic membrane could emit an infinite number of notes, and that there would be an infinite discontinuous scale of them, going from the lowest tone to the highest. The example of sounds produced by an elastic cord or by a rod is sufficient to suggest what ought to happen when one passes from the case of a single dimension to that of two dimensions, and even what ought to result from the consideration of a vibrating body of three dimensions. But for mathematicians it was necessary to give a rigorous proof, and this proof was complicated and hard to find. We must not even suppose that the analytic investigation had the aim of calculating the pitches of the various notes. Any practical application of the calculation was quite far from the thought of the mathematician. It was only the logical point of view which gave importance to the question. Its difficulty increased its attraction and it thus became a question of compelling interest.

Physicists were intuitively aware of the result, not merely on account of the analogy of which I have just spoken, but also from a certain process of induction which has a philosophic value of the highest order, and which can be regarded as the source of several investigations which continued after Poincaré. Lagrange had devoted a chapter of his "Analytic Mechanics" to the theory of small motions. This chapter is one of the finest of his work. The author was able to carry through all the integrations in the case which he was considering, and obtained very simple and interesting formulæ. The periods of vibration of any set of molecules, finite in number, connected among each other by arbitrary restraints, were obtained by Lagrange by means of the roots of an

algebraic equation. Now any system can evidently be considered as a collection of molecules arranged in a space of one, two or three dimensions according as we consider a cord, a stretched membrane or a solid body. It is sufficient then to replace the finite number of molecules of Lagrange by these collections which we have mentioned in order to extend his results to the different cases. This is really what is called Lord Rayleigh's principle, and gives a very clear and suggestive point of view in regard to the bearing of the problem. But this principle was not sufficient demonstration for mathematicians.

The question which we have just been considering from the point of view of the theory of sound, is presented also, either in quite the same manner or in similar form, in several other questions of mathematical physics. We meet it when we consider other vibrations which are not acoustical—for instance, those that are electromagnetic. We meet it also in questions of another nature, such as those of the theory of heat.

A single result had been demonstrated rigorously since 1885, in such a way as to satisfy every mathematician. That was the analytic proof of the existence of the fundamental tone—that is to say, the one which corresponds to the absence of nodes and nodal lines in the vibrating membrane. Schwartz had obtained that result when studying certain questions of a different nature. For a long time he had been developing the theory of minimal surfaces—that is to say, the surfaces of equilibrium of a very thin liquid layer in which there is a surface tension (for instance, a layer of water in which soap is dissolved). In the problem of the calculus of variations, to which he was led, it was necessary to distinguish the maxima from the minima. He was thus led to consider the following question: A function of two variables vanishes at the boundary of a region of two dimen-

sions. The ratio of the value of its differential parameter of the second order to its own value is a negative constant at all points of the region. What is the smallest absolute value of this constant? Now the problem of the notes produced by the vibrations of the membrane consists in finding all the values of this ratio. That is why Schwartz's problem is only a particular case of the one we are considering.

The question then was to proceed to calculate all the other values beyond Schwartz's minimum. Already M. Picard had discovered properties of the greatest importance in this direction, and Poincaré had attacked the problem in a work which was published in the American "Journal of Mathematics," but it must be confessed that in this work he was still far from the solution. He took his revenge in the paper which we are about to examine.

We should guess from Lagrange's theorem and Lord Rayleigh's principle that the different pitches ought to appear as the roots of a transcendental function. It was the construction of one of these functions, or, more particularly, the proof of its existence, that Poincaré attempted. Let us see how.

He commences by adding a term to his equation—that is, he considers one that is made up of three terms. The first is the differential parameter of the second order, the second is the unknown function multiplied by a parameter, and the last is a function which he takes as arbitrary. We shall call this equation the auxiliary equation. The primitive equation lacked just this last term. He constructs this arbitrary function by linearly composing n functions by means of certain constant undetermined coefficients. This done, he develops the unknown function, supposed zero on the boundary, in a series of powers of the parameter. This result is reached by the use of Green's functions. He gets in this way an analytic function of the parameter for which

the development is valid within a certain circle, and which can be also represented as the ratio of two functions of which the denominator is independent of the variables of integration. By means of processes of extreme subtlety he shows that these undetermined coefficients of which we have just spoken can be chosen so that the two functions shall be entire functions of the parameter. Hence if in the auxiliary equation we replace the unknown function by the ratio of the two functions, giving them this entire form, we see that for all the values of the parameter which make the denominator vanish the auxiliary equation reduces to the primitive equation, and thus it comes about that all the roots of the entire function which appears as the denominator give the values which we were looking for.

Nothing can be simpler than this process which I have been able to summarize in so few words, but it contains a group of thoughts of a marvelous subtlety and fruitfulness.

What I have given is only the first part of Poincaré's memoir. The study of the roots of the functions which resolved the primitive equation, their properties, the developments that they followed, the definite applications to the problems of acoustics and of the theory of heat, give a number of very important results. They have been applied to many similar questions. At present this classic memoir remains as one of the finest monuments constructed by Poincaré; but it is with the methods of integral equations that we now study those problems. Leaving these questions here, however, let us pass on to other problems and investigations.

Some years ago it seemed for a time as if the atomic and corpuscular theories were losing ground. People thought that everything could be explained by means of continuous substances. In mathematical physics partial differential equations were obtained by abandoning entirely the molecular hypothesis. In chemistry also it was heard that the atoms

were becoming useless. But a sudden breath dispersed the light clouds which seemed to obscure the corpuscular theories. They are now supreme, and serve to illuminate the various regions of natural philosophy.

Necessarily the old atomic theories continued to advance. Electricity was first recognized as being of corpuscular nature, and little by little in every subject new sorts of atoms appeared. People discovered facts that accorded with the new theories. These theories became even the richest and most fruitful source of new discoveries, and it is for that reason that their reputation has increased from day to day. It has become now so secure that when contradictions are unavoidably presented we do not think of giving up these new ideas, but, rather, have not hesitated to abandon ancient principles whose validity was not doubted enough even to discuss. Little by little the classic theories which seemed set upon eternal foundations have been upset. Even mechanics, which, after Galileo and Newton, came to be regarded as the most secure of all sciences, has been overturned. A new mechanics has been formed, that of relativity. But that perhaps is already to-day an old mechanics. Will there not come from it indeed again an entirely new one, by virtue of the concept of atoms of energy?

Poincaré was associated with the transformation of the old physics and the birth of the new. His criticism and analysis have penetrated modern conceptions from all sides. He was devoted to such questions up to the end of his life, and several of his articles and latest lectures were given to their exposition. And so Poincaré was not only a master in the first kind of mathematical physics, but also in the second.

The electrodynamics of bodies at rest did not present great difficulties after the discoveries of Maxwell and the progress due to Hertz. But that of bodies in motion gave

rise to much discussion. Hertz had suggested a special hypothesis in order to pass from the case of rest to that of motion, but experiment proved it to be false, and it is Lorentz's theory which now explains best the latter subject. The celebrated discovery of Zeeman was a great triumph for the conceptions and hypotheses of Lorentz, because these conceptions and hypotheses predicted the doubling of the lines of the spectrum in a magnetic field; and this was the result verified by Zeeman's experiment.

Lorentz's theory was the source of a new order of ideas, including that which I have called the new mechanics. His theory was put in comparison with the principles of mechanics and physics. No contradiction appears with the principles of the conservation of energy or with those of electricity and magnetism. But at the first step a question is suggested to us, namely: Is it possible to determine explicitly the "absolute" motion of bodies, or, rather, their motion relative to the æther, by means of optical or electromagnetic phenomena?

To make the question still more precise: Do optical or electromagnetic phenomena serve to determine the absolute motion of the earth?

If we take account only of the first power of the aberration, the motion of the earth has no influence on any of these phenomena. This negative result has been shown by experiment, and is perfectly explained by Lorentz's theory.

But a celebrated experiment was performed by Michelson and Morley which kept account of the terms depending on the square of the aberration, and even this experiment, as is well known, gave a negative result.

In a famous paper of 1904 Lorentz showed that this result could be explained by introducing the hypothesis that all bodies are subjected to a contraction in the direction of the motion of the earth.

This paper was the point of departure for the later investigations. The results of Poincaré, Einstein and Minkowski followed closely that of Lorentz. In 1905 Poincaré published a summary of his ideas in the "Comptes Rendus" of the French Academy of Sciences. An extended memoir on the same subject appeared shortly afterwards in the "Rendiconti" of Palermo.

The basic idea in this set of investigations is founded upon the principle that no experiment could show any absolute motion of the earth. That is what is called the *Postulate of Relativity*. Lorentz showed that certain transformations, called now by his name, do not change the equations that hold for an electromagnetic medium; two systems, one at rest, the other in motion, are thus the exact images each of the other, in such a way that we can give every system a motion of translation without affecting any of the apparent phenomena.

In Lorentz's theory a spherical electron in motion takes the form of an oblate spheroid, two of its axes remaining constant. Poincaré found the particular force necessary to explain both the contraction of the electron and the constancy of the two axes. This is a constant exterior pressure acting upon the deformable and compressible electron. The work performed by this force is proportional to the variation in volume of the electron. In this way, if inertia and all of the forces are of electromagnetic origin, the postulate of relativity can be rigorously established.

But according to Lorentz all forces, no matter what may be their origin, are affected by his transformation in the same way as the electromagnetic forces. What modifications will it be necessary to introduce into the laws of gravitation, in virtue of this hypothesis?

Poincaré finds that gravitation must be propagated with the velocity of light. We might think, knowing the famous

theory of Laplace, that that was in contradiction with astronomical observations. But that is not so; there is a compensating term which removes every contradiction. Poincaré was thus led to propose and resolve the following question: To find a law which satisfies the condition of Lorentz and reduces to Newton's law when the squares of the velocities of the stars are negligible in comparison with the velocity of light.

Those are the fundamental problems and ideas of Poincaré, which have played such an important part in all later researches. The methods employed involve the principle of least action and the theory of groups of transformations, because Poincaré finds that the transformations of Lorentz form a group in Lie's sense. It is enough to have recalled these general ideas. At the present time they are much spoken of. They form the subject of such a great number of scientific papers and popular conferences that everybody knows them and appreciates their importance.

We shall close by speaking of Poincaré's contribution to mechanics. It is the hardest part of his work to analyze. He concerned himself with practically every branch of analytical mechanics: problems of stability, celestial mechanics, hydrodynamics and potential. The problem of the three bodies forms the subject of a great number of his investigations, now become famous, since they aided in revolutionizing classical methods. As is well known, it was Poincaré's memoir on "The Three-body Problem and the Equations of Dynamics" which was crowned with the prize founded in 1889 by King Oscar of Sweden. Important works of Poincaré's followed this memoir: the three volumes entitled "Les méthodes nouvelles de la mécaniques céleste," and the "Leçons" given at the Sorbonne. Moreover, Poincaré's last expository work was devoted to the discussion of the various cosmogonic hypotheses.

The fundamental ideas which guided Poincaré in the problems of mathematical astronomy were the consideration of periodic solutions, the study of the series which give the solution of the problem of three bodies, and the introduction of integral invariants. We have a periodic solution of the problem of three bodies if at the end of a certain time the three bodies are found again in the same relative positions, the whole system being merely turned through a certain angle. By considering the eccentricities and inclinations of the orbits, Poincaré was led to distinguish three kinds of periodic solutions for values of the time infinitely great either negatively or positively.

These studies on periodic solutions have very great theoretical interest, but also they have important practical applications. At a first glance, we can understand that the probability is infinitely small that in any practical problem the initial conditions of the motion will be such as to correspond to a periodic solution. Nevertheless, we can take one of these periodic solutions as a starting-point for a series of successive approximations, and thus study those solutions which differ little from it.

It is well known that a beautiful application of this method was made by Hill to the theory of the moon's motion.

The question of divergence of the series which appear in celestial mechanics has great importance. It is one of the most interesting questions that have arisen in mathematics. Can we use divergent series, and can we by means of series of this kind arrive at approximate solutions of practical problems? The example of Stirling's series allows us to answer in the affirmative. We find series of the same kind in celestial mechanics. They also furnish approximate values sufficient for the demands of practice. That is what Poincaré noticed and proved.

The celebrated theorem about the non-existence of uni-

form integrals—that is to say, that the three-body problem has no uniform integrals besides those already known—is one of the most remarkable results of Poincaré's theory.

In these researches about which we have been speaking the so-called integral invariants play an essential part. These are approximations which are calculated by quadratures applied to the variables of differential equations, and remain constant. These invariants are connected intimately with the fundamental question of stability.

It is impossible to summarize all these theories and yet present them clearly. On the other hand, to develop them more minutely would carry us too far.

Following the same path that we have taken for analysis and mathematical physics, let us then consider also in mechanics a particular one of Poincaré's investigations, sufficient to show us the range and powerful originality of his genius. On the one hand, this investigation is related to hydrodynamics; and on the other, to celebrated questions of celestial mechanics and, as Sir George Darwin has shown, to the most interesting and modern cosmogonic theories.

It is the question of the equilibrium of a rotating fluid mass, and was one of the first problems that presented themselves with the establishment of the theory of gravitation. MacLaurin gave a solution of it by means of ellipsoids of revolution, and it is perhaps the finest result which that great geometer gave to science. The solution by Jacobi by means of ellipsoids with three unequal axes was a happy stroke of genius of that illustrious mathematician. He was in fact the first to doubt what everybody considered as evident *a priori*—that is, that every possible form of equilibrium of a rotating homogeneous fluid mass is symmetric in regard to the axis of rotation.

But solutions due to MacLaurin and Jacobi were only particular solutions of the general problem. There are an

infinite number besides. We must also notice that these particular solutions were not obtained directly. It was merely verified that under certain conditions certain ellipsoids satisfied the laws of equilibrium.

Before considering Poincaré's investigation we must recall the fact that Thomson and Tait in their treatise on natural philosophy had seen that there were ring forms of equilibrium as well as ellipsoids. They had also studied the question of stability, either by imposing certain conditions on the fluid mass—for instance, that of being a solid of revolution or of being ellipsoidal—or by omitting such conditions.

The fruitful idea of Poincaré was that of equilibrium of bifurcation. Let us consider a system whose state depends on a certain parameter. If, for instance, we have a rotating fluid mass, we can let that parameter be the angular velocity of rotation. Let us suppose that several different forms of equilibrium correspond to the same value of the parameter. Let us change that value. The configurations—or, in other words, the forms of equilibrium—will change. It may happen, that, on approaching a certain limit, two forms of equilibrium become the same. If we go by this limit we may have one of two cases. The figures of equilibrium may disappear; we express this in algebraic language by saying that they become imaginary. That is the first case. We say then that that form which the two figures approach is a limiting form. But it may happen that if we pass the limiting value the two distinct figures reappear. That is the second case. In this case the figure where the two forms of equilibrium coincide is called a *form of bifurcation*.

Let us suppose ourselves to be able to represent each figure of equilibrium by a point in the plane of which the coördinates are the value of the parameter and some vari-

able which distinguishes the figure. By changing the parameter we shall have a curve. In our second case this curve is formed of two branches which cross, corresponding at their intersection to the form of bifurcation. Now Poincaré established a theorem of the greatest importance by considering the stability of the figures corresponding to the different points of the two branches. Let O be the value of the parameter which refers to the point of intersection. If for negative values of the parameter there is stability on the first branch and instability on the second, it will be the opposite for positive values of the parameter—that is, there will be instability on the first branch and stability on the other. In other words, there is an exchange of stabilities between the two branches at the place where they cross. This proposition was called by Poincaré the *theorem of the exchange of stabilities*.

Let us now apply these results to the question of the rotation of fluid masses. Let us suppose that we know the solutions of MacLaurin and Jacobi. The axis of rotation is always the small axis of the ellipsoid, and so we know that its ratios to the other axes are less than unity. These ratios are equal for MacLaurin's ellipsoid and different for that of Jacobi. If

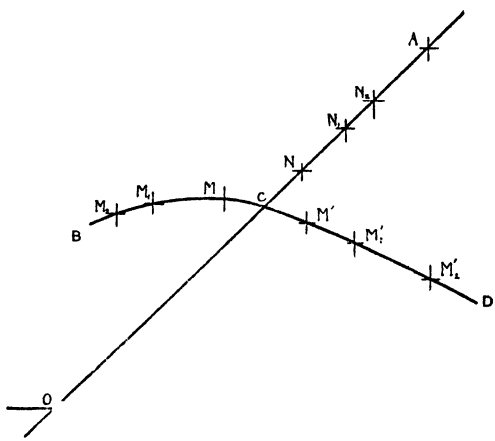

FIGURE 1

we take these ratios as coördinates of a point in the plane, each ellipsoid will be characterized by a point, and these points will form a curve (see Fig. 1). The bisector of the angle between the axes will be the line that represents the ellipsoids of MacLaurin. The curve BCD will represent the ellipsoids of Jacobi.

But Poincaré also found new figures of equilibrium that can be obtained by deforming the ellipsoids. The exact form can be calculated by means of Lamé's functions. The simplest have the form of a pear. It is shown that there exist an infinite number of ellipsoids of MacLaurin that correspond to the points N, N_1, N_2 . . . . of the line AO such that one of the infinitely near figures of Poincaré is also a form of equilibrium. In the same way there are an infinite number of points M, M_1, M_2 . . . . M^1, $M^1{}_1$, $M^1{}_2$ . . . . of the curve BCD such that the neighboring Poincaré figure is also a form of equilibrium.

Let us consider now the stability. The MacLaurin ellipsoids are stable in the part AC, and unstable in the part CO. The ellipsoids of Jacobi are stable from C up to the first point M, where one encounters a figure of Poincaré, and unstable in the part MB.

Hereupon we come to an application of the theory. I quote from Poincaré himself:

"Let us consider a homogeneous fluid initially rotating and cooling slowly. If the cooling is slow enough the internal friction determines that the whole mass revolve with the same angular velocity at all points. The moment of rotation will moreover remain constant.

"At the beginning, since the density is very small, the form of the mass is an ellipsoid which will hold together despite the revolution. The representative point will describe the portion AC of the line which corresponds to the MacLaurin

ellipsoids up as far as C, where these ellipsoids become unstable. The representative point, which can no longer take the path CO, will then follow, for instance, the direction CM; the ellipsoid will have its three axes unequal, and this is true as far as M, where the Jacobi ellipsoids become unstable. Beyond this stage, since the mass can no longer keep the ellipsoidal form, that having become unstable, it will take on the only form possible, which is that of the neighboring surface to it. This surface is a piriform figure (see Fig. 2) which has a narrow place in the region marked 3; the regions 2 and 4 tend to increase at the expense of the regions 1 and 3, as if the mass were trying to divide in two unequal parts."

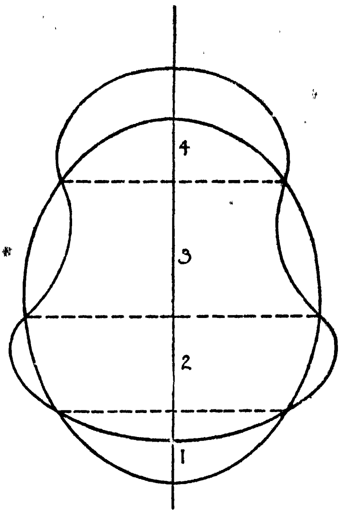

FIGURE 2

The results that we have just presented are quite elegant and of great importance. They revealed much to Sir George Darwin. He thought that the process which we have just described might play a part in the evolution of celestial systems, and this theory seems to be confirmed according to the forms observable in many nebulæ. Some satellites may have been formed in this way at the expense of their planets. In particular that may have happened in the case of the earth and the moon, the masses of which are comparable in magnitude.

Under these majestic aspects, where the most subtle and ingenious theories of mechanics are at one with the most

daring cosmogonic hypotheses, we finish our analysis of the investigations due to Poincaré.

I have given but an incomplete idea of the immense work which he did, of the problems which he treated and which it will be necessary to study exhaustively, of the regions which he has opened where several generations of mathematicians will be able to work.

His discoveries will but have the result of stimulating new investigations. That is the fate of the works of great geniuses. They give the key for solving many problems and satisfy scientific curiosity by unveiling the secrets of nature, but at bottom they merely increase that curiosity by opening new horizons and making still more distant the goal of scientific aspiration.

VITO VOLTERRA.

MOLECULAR THEORIES AND MATHEMATICS[1]

HOW could I fail to call up the memory of the illustrious scientist for whose death, so cruelly premature, France and the whole world are mourning? When Henri Poincaré was invited by President Edgar Odell Lovett to deliver an address at this scientific celebration, his acceptance was conditional on the state of his health. A few months later, he finally declined the invitation, promising, however, to send his lecture in writing. I cannot remember without emotion the last conversation I had with him on that subject. I was still hoping that his decision was not final; but, after giving me some friendly advice about my lectures and the journey, he told me with what deep regret he had to give up the thought of ever visiting the United States again, and I felt, for the first time, how serious was the condition which justified his refusal. A few weeks afterward he was gone. In spite of the difficulties of such a task, I should have considered it a pious duty to devote this address to an appreciation of his work; no subject could be more suitable, in this Institute consecrated to science, than the life and works of this noble champion of disinterested research; but my eminent friend Mr. Vito Volterra had, as you know, formed the same plan; and no one among you will regret that I resigned to him the privilege of carrying it out.

[1] An address delivered at the inauguration of the Rice Institute, by Emile Borel, Professor of the Theory of Functions in the University of Paris. Translated from the French by Professor Albert Léon Guérard of the Rice Institute.

I

THE relations between the mathematical sciences and the physical sciences are as old as these sciences themselves; it is the study of natural phenomena which led man to set for himself the first problems, out of which, by means of abstraction and generalization, the sciences of numbers and of space have grown in all their splendid complexity. Conversely, through a sort of preëstablished harmony, certain mathematical theories, after being developed apparently far from the real, were often found to provide the key to phenomena which the creators of these theories did not have in mind. The most famous instance in point is the theory of conic sections, an object of pure speculation among the Greek geometers, but whose researches enabled Kepler, twenty centuries later, to formulate with precision the laws of the motions of the planets. In the same way, in the first half of the nineteenth century, it was the theory of imaginary exponentials which made it possible to go deeper into the study of vibratory motions, which was found to be of such commanding importance in physics and even in the field of industry; it is to this study that we owe wireless telegraphy and the transmission of energy by polyphase currents. More recently still, we know how useful the abstract theory of groups proved to be for the study of the ideas, so profound and so new, which have been put forward to explain the results of the capital experiments on relativity made by your illustrious compatriot Michelson.

But these illustrations, however important they may be, are special and relate to particular theories. How much more striking is the universal adoption of the forms imposed on scientific thought by the genius of Descartes, Newton,

Leibnitz! The use of rectangular coördinates and of the elements of differential and integral calculus has become so familiar to us that we might be tempted at times to forget that these admirable instruments date only from the seventeenth century, and in the same way the theory of partial differential equations dates only from the eighteenth century: it was in 1767 that d'Alembert obtained the general integral of the equation of vibrating chords. It was the study of physical phenomena which suggested the notions of continuity, derivative, integral, differential equation, vector, and the calculus of vectors, and these notions, by a just return, have become part of the scientific equipment necessary to every physicist: it is through them that he interprets the results of his experiments. There is evidently nothing mysterious in the fact that mathematical theories constructed on the model of certain phenomena should have been capable of being developed and of providing a model for other phenomena; this fact, however, deserves to hold our attention, for it implies an important practical consequence; if new physical phenomena suggest new mathematical models, mathematicians will have to study these new models and their generalizations, with the legitimate hope that the new mathematical theories thus evolved will prove fruitful in their turn in providing the physicists with useful forms of thought. In other words, to the evolution of physics there should correspond an evolution of mathematics which, without giving up the study of classical and well established theories, should develop in taking into account the results of experience. It is in this order of ideas that I should like to examine to-day the influence which molecular theories may have on the development of mathematics.

II

It was in the hypothesis of the continuity of matter that, at the end of the eighteenth century and in the first half of the nineteenth, what may be termed classical mathematical physics was created; one may take as types of the theories thus constructed hydrodynamics and elasticity. In hydrodynamics every liquid was considered by definition as homogeneous and isotropic; it was not quite the same in the study of the elasticity of solid bodies: the theory of crystalline forms had led physicists to admit the existence of a periodic network—that is to say, of a discontinuous structure; but the period of the network was supposed to be extremely small compared with the elements of matter physically considered as differential elements; the crystalline structure therefore led only to anisotropy, but not to discontinuity; the partial differential equations of elasticity as well as those of hydrodynamics imply that the medium studied is continuous.

Yet the atomic hypothesis, the tradition of which goes back to the Greek philosophers, was not abandoned; apart from the confirmation which it found in the properties of gases and in the laws of chemistry, it was by means of that hypothesis that certain phenomena, such as the compressibility of liquids or the permeability of solids, had to be explained, in spite of the apparent continuity of these two states of matter; but this hypothesis was placed in juxtaposition with the physical theories based on continuity: it did not affect them. The rapid advances in thermodynamics and in the theories of energy contributed to maintain this sort of impenetrable partition between the physical theories and the hypothesis of the existence of atoms, however fruitful this might prove to be in chemistry. For most of the physicists of half a century ago the problem of the reality of atoms

was a metaphysical question, in the original acceptance of the term, a question beyond the domain of physics; it mattered little to science whether atoms existed or were simple fictions, and one might even doubt whether there was any sense in affirming or denying their existence. However, thanks especially to the labors of Maxwell and of Boltzmann, the explicit introduction of molecules into the theory of gases and solutions was proving its fruitfulness; and Gibbs created the new study to which he gave the name Statistical Mechanics. But it is only within the last twenty years that all physicists have been compelled, by the study of new radiations on the one hand, and by the study of the Brownian movement on the other, to consider the molecular hypothesis as indispensable to natural philosophy. And more recently a more thorough study of the laws of radiation has led to the unexpected hypothesis of the discontinuity of energy, or of motion. It does not come within my subject to expound the experimental proofs which make these hypotheses seem more and more probable every day; the most striking experiments are perhaps those which have made it possible to observe the individual emissions of the α particles, so that we are actually able to apprehend one of the concrete units with which the physicist builds up the sensible universe, just as the abstract universe of mathematics can be built up by means of an abstract unit.

In order definitely to formulate their hypotheses and to deduce therefrom consequences that can be experimentally verified, the theorists of modern physics make use of mathematical symbols; these symbols are those which were created on the basis of the notion of continuity; no wonder, therefore, if difficulties sometimes appear, the most recent of which is the contradiction, at least in appearance, between the hypothesis of the *quanta* and the older hypothesis that

phenomena are governed by differential equations. But these difficulties of principle do not prevent the success of what may be called partial theories, by which a certain number of experimental results, in spite of their apparent diversity, can be deduced from a small number of formulæ which are coherent among themselves; thus, for many of the phenomena of physical optics, the formulæ are the same in the mechanical theory of Fresnel and in the electromagnetic theory of Maxwell; in the same way, the formulæ used by electrical engineers are independent of the diversity of theories concerning the nature of the current.

If I have made it a point to call your attention to this use of the mathematical instrument as an auxiliary to the partial physical theories, although it does not lie within my subject, it is in order to prevent any misunderstanding: it seems to me beyond doubt that for a long time to come—perhaps as long as human science itself shall endure—it will be under this comparatively modest form that mathematics will prove of greatest use to physicists. This is no reason why we should take no interest in the general mathematical theories for which physics has provided the models, whether we have to deal with speculations on partial differential equations suggested by the physics of the *continuum*, or with statistical speculations pertaining to the physics of the *discontinuum;* but it should be clearly understood that the new mathematical theories which may be suggested by the discontinuity of physical phenomena cannot have the pretension of entirely replacing classical mathematics; these are only new aspects, for which it is proper to make room by the side of the older views, so as to increase as much as possible the richness of the abstract world, wherein we seek for models which will make us understand concrete phenomena better and foresee them more accurately.

III

It is frequently a simplification in mathematics to replace a very large finite number by infinity. Thus the calculus of definite integrals is frequently more simple than that of summation formulæ, and the differential calculus is usually simpler than that of finite differences. In the same way, we have been led to replace the simultaneous study of a very large number of functions of one variable by the study of a continuous infinitude of functions of one variable; that is to say, by the study of a function of two variables. By a bolder generalization, Professor Vito Volterra has been led to define functions which depend on other functions—that is to say, in the simplest case, functions of lines, in considering them as the limiting cases of functions which would depend on a great number of variables, or, if one prefers, on a very great number of points of the line.

These various generalizations have rapidly secured permanent recognition in mathematical physics; the use of integral equations, the classical types of which are the equation of Volterra and the equation of Fredholm, has become current. Although these theories are well known to all, it may not be idle to recall their origin by means of a particularly simple example; we shall thus better understand their significance from our present point of view.

Let us consider a system composed of a finite number of material points, each of which can deviate only by a small amount from a certain position of stable equilibrium. The differential equations which determine the variations of these deviations from their position of equilibrium may be considered, under certain hypotheses and to a first approximation, as linear in respect to these deviations. If, moreover,

we introduce the hypothesis that the system conforms to the law of the conservation of energy, the differential equations assume a very simple and classical form, from which the fact can easily be deduced that the motion may be considered as the superposition of a certain number of periodic motions. The number of these elementary periodic motions is equal to the number of degrees of freedom; it is three times the number of the material points, if each of these points can be arbitrarily displaced in the neighborhood of its position of equilibrium. The periods of the simple periodic motions are the *specific constants* of the system, which depend only on its configuration and the hypotheses made concerning the forces brought into action by its deformation, but which do not depend on the initial conditions: positions and velocities. These initial conditions determine the arbitrary constants which figure in the general integral and which are two in number for each period: the intensity and the phase.

Now let us suppose that the number of material points becomes very large, and let us identify each of them with a molecule of a solid body—a bar of steel, for instance; if our hypotheses are still verified—and this is admitted in the theory of elasticity—their consequences also will remain true; we shall then have a very large number of characteristic constants, each of these constants defining a proper period of the system. Let us increase to infinity the number of molecules; the system of differential equations, infinitely great in number, is then replaced by a finite number of partial differential equations, whose fundamental properties are obtained by passing to the limit. In particular, the proper periods can be determined, and this remarkable result is established—that these periods can be calculated with precision and without ambiguity if we take the precaution of defining them by commencing with the longest; there is only

a finite number of periods superior to a given interval, but this number increases indefinitely when the interval tends toward zero.

The reasoning which has just been outlined is the type of those to which the substitution of continuity for discontinuity leads; in reality, the considerations based on the existence of molecules play but an auxiliary part in them; they put us on the track of the solution, but this solution, once arrived at, satisfies rigorously the partial differential equations of Lamé, equations which can be deduced just as well from theories of energy as from molecular hypotheses. The molecular theory has therefore been a valuable guide for the analyst in suggesting to him the course to be followed in studying the equations of the problem, but it is eliminated from the final solution. On the other hand, we know that this solution is but an imperfect representation of reality; we obtain an infinitude of proper periods, instead of a very great number of them; the actual number, however, is so great that we ought not, perhaps, to feel any scruple in passing to the limit and considering it as practically infinite. If, however, one bears in mind that the difficulties of the theory of black radiation arise precisely from the very short periods, and that these difficulties are not yet solved in an entirely satisfactory manner, one will perhaps come to the conclusion that one could not be too careful about anything which relates to these very short periods. This is probably the reason why such a physicist as Lorentz has thought that the considerable analytical efforts required by the study of the propagation of waves, when molecules are explicitly introduced into it, were not superfluous. However this may be, even if the substitution of the infinite for the finite is entirely legitimate in certain problems, it may be interesting to propose to one's self, from a purely mathematical point of view, the direct

study of functions or equations depending upon a great but finite number of variables.

IV

The first difficulty which presents itself, when one wishes to study functions of a very great number of variables, is the exact definition of such a function—I mean its *individual* definition—making it possible to distinguish the function thus defined from the infinitude of other analogous functions. It is true that there exist general properties common to all the mathematical entities of a certain category, independent of the numerical value of the coefficients; for instance, every definite quadratic form (that is to say, one always positive) is equal to the sum of the squares of as many independent linear functions as the number of the variables which it contains. One has at times attempted to deduce physical consequences from mathematical facts of that kind; I must confess that I cannot help being skeptical about this sort of reasoning; it may seem rather strange that one should be able to deduce anything exact from such a general notion as that of a surface of the second degree (let us say, for fixing ideas, a generalized ellipsoid) in a space having a very great number of dimensions. Let us insist a little on the difficulty there is in knowing such an ellipsoid *individually:* its equation may be supposed to be reduced to a sum of squares by an orthogonal substitution—that is to say, the axes remaining rectangular. Such an ellipsoid then requires, for its complete definition, the knowledge of what we may call the squares of the lengths of its axes—that is to say, the knowledge of as many positive numbers as the space considered has dimensions. The question of knowing whether one can consider as *given* so many numbers, when a man's lifetime would not suffice to enumerate a small part of them, is

a question which is not without analogy with that of the legitimacy of certain reasonings of the theory of ensembles, such as the one by which Professor Zermelo pretends to prove that the continuum can be well ordered, and which supposes to be realized an infinitude of choices independent of any law, and yet uniquely determined. Opinions may differ on the theoretical solution of these difficulties, and this is not the moment to reopen this controversy; but from the practical point of view, the answer is not doubtful: it is not possible effectively to write the numerical equation of an ellipsoid whose axes are as numerous as the molecules constituting a gram of hydrogen.

In what sense then is it possible to speak of a numerically determined ellipsoid possessing a very large number of dimensions? From an abstract point of view, the simplest method for *defining* such an ellipsoid consists in supposing that the lengths of the axes are equal to the values of a certain function which is simple for the integral values of the variable; one may suppose them to be all equal (in which case one will say that the ellipsoid is reduced to a sphere); one may also suppose that their values are the successive integral numbers in their natural sequence, either starting from number one or from any other given number; or that they are equal to the inverses of the squares of these integers, etc. In other words, we suppose that the lengths of the axes are all determined by the knowledge of a formula simple enough to be actually written, whereas it is not possible actually to write as many distinct numbers as there are axes.

Another method, to which we are naturally led by the analogies with the kinetic theory of gases, consists in supposing that the values of a function of the axes, such as the square of the lengths of the axes, or of their inverses, etc.,

are not individually given, but that we know only the mean value of this function, and the law of the distribution of the other values around this mean. We propose, under these conditions, not to study the property of a unique and well defined ellipsoid, but only the most probable properties of the ellipsoid, knowing only that it satisfies the required conditions; we can also say that we study the mean properties of the ensemble of the ellipsoids defined by these conditions. Here again we may observe that the probable ellipsoid or the mean ellipsoid is completely defined by the knowledge of the mean value of the law of deviations. If this law is the classic law of probabilities, it includes only two constants; if we were led to introduce a more complicated law, this law might in all cases be explicitly written. The two processes that we have indicated are therefore equivalent from the analytical point of view; it would evidently be the same with all other processes that could be imagined, and in particular with the combinations of these two.

In a word, a figure which depends on an extremely great number of parameters can be considered as numerically determinate only if these parameters are defined by means of numerical data sufficiently few in number to be accessible to us. It is for this reason that the study of the geometrical figures in a space possessing an extremely great number of dimensions can lead to general laws if we can exclude from this study such of these figures as, humanly speaking, cannot possibly be defined individually.

Here are, for example, some of the results to which the study of ellipsoids leads us. In working the equation in the form of a sum of squares, the second member being reduced to unity, the coefficients are equal to the reciprocals of the squares of the axes. If the mean of the squares of these coefficients is of the same order of magnitude as the square

of their mean, one will say that the ellipsoid is not very irregular. The modes of definition concerning which we have just spoken lead to ellipsoids which are not very irregular, since one does not systematically introduce into those definitions functions purposely chosen in a complicated manner. On the contrary, one gets a very irregular ellipsoid in equating to a constant the *vis viva* of a deformable system composed of a very great number of molecules, this *vis viva* being written under the classic form of the sum of the *vis viva* of translation of the total mass concentrated at the center of gravity, increased by the sum of the *vires vivæ* of the molecules in their motion relative to this center of gravity. The great irregularity comes from the fact that the products of the total mass by the three components of the velocity of the center of gravity are extremely great in comparison with the otner terms. When an ellipsoid is not very irregular, several of its properties make it possible to assimilate it to a sphere, which may be called the median sphere; the surface of the ellipsoid is almost wholly comprised between the surfaces of two spheres very close to the median sphere; on the other hand, if a point is arbitrarily chosen on the ellipsoid, it is infinitely probable that the normal at this point passes extremely close to the center.

This geometrical study of figures with a very large number of dimensions deserves, I believe, to be thoroughly investigated; it brings out the abstract basis of the theories of statistical mechanics and physics—that is to say, it enables us to distinguish, among the propositions to which physicists are led, those which are a consequence of physical hypotheses from those which are derived only from statistical hypotheses. But, apart from its physical usefulness, this geometrical study of spaces having a very great number of dimensions offers an interest of its own; it is to the

molecular theories that we are indebted for this new branch of mathematics.

V

We can, however, ask ourselves whether it is legitimate to consider as bound up with the molecular hypothesis a theory which, after all, should depend exclusively on a small number of constants. To say that an ellipsoid with a great number of dimensions is entirely defined by five or six constants, amounts to saying that all the consequences which we shall deduce from its study can be expressed by means of these five or six constants. Can we not suppose, then, that an analytical mechanism could be devised, enabling us to arrive at these same consequences, expressed by means of the five or six constants, without its being necessary to bring in the equation with a very great number of terms—that is to say, without its being necessary to make use of the molecular hypothesis.

This objection deserves careful consideration, although it reminds us of the controversy between the energetists and the atomists, a controversy in which the advantage seems decidedly to have been on the side of the atomists. It may be answered, in the first place, with an argument of fact: it matters little that we might conceive the possibility, without making use of molecular hypotheses, of combining among themselves the consequences of these hypotheses; the important point is to know whether this possibility is realized at present, or if, on the contrary, the calculations based upon molecular hypotheses are the simplest, if not the only, mode of deduction. If the latter alternative be correct, and it seems difficult to deny that it is, molecular hypotheses are therefore at present very necessary indeed, and that alone ought to be of consequence to us.

Under this modest form, which leaves room for future contingencies, this reply seems peremptory; but I believe that many physicists would think it is not categorical enough. It must be noted, however, that the question is independent of the experimental proofs of the reality of molecules. Even if we should succeed in seeing, by means of an instrument more powerful than a microscope, the molecules of a solid body, it would not follow, however valuable this knowledge might be, that one should have to use it in order to account, in the simplest possible manner, for the properties of that body; in a similar way, the possibility of seeing an isolated microbe under the microscope is not an indispensable condition for the attenuation of the viruses and the use of vaccines; or again, in the reproduction of a masterpiece by photogravure, it is not the individual knowledge of the points constituting the negative that interests us.[1]

From an abstract point of view, if we admit that any human theory must be expressed, in last analysis, by means of a finite and relatively small number of data, it seems difficult to deny the possibility of entirely constituting the theory, without introducing hypotheses which imply the existence of elements more numerous than human imagination can conceive. But the recognition of this abstract possibility cannot prevail against the importance of the services rendered by molecular theories in linking together apparently unrelated phenomena; so it is permissible to consider these reserves on future possibilities as purely theoretical.

[1] This individual knowledge of points has a part in the processes for transmitting the negative to a distance; but in this case these points, however numerous, are none the less finite in number and accessible to our observation. If we transmit by telephone an orchestral selection, we know that all the æsthetic beauties of the piece are, in last analysis, the results of certain vibrations which would require too much time to be known individually; but in fact these elementary vibrations have nothing to do with musical æsthetics: an excellent composer may be ignorant of their existence, and an excellent physicist may be a wretched musician.

Is it possible to go still further, and to do away even with this kind of reserve? In order to answer this question, we should have to examine in detail all the phenomena which are explained by means of molecular hypotheses, and to try to ascertain whether an extremely large number of parameters is indeed necessary to such explanation. Among the discontinuous phenomena whose experimental laws are well known, the most characteristic are those of spectra in series; we know that the positions of the spectral rays are determined with a very great precision by formulæ, the first and simplest of which, due to Balmer, includes the difference of the reciprocals of the squares of two integers. This is perhaps the most remarkable example of the intervention of the integer in natural law; if laws of this kind were more numerous and better known, one might possibly be led to name arithmetic and the theory of numbers among the branches of mathematics which can be connected with molecular physics. Can one, by induction, admit that the formula of Balmer is exact, not only for small integers concerning which the experimental verification is rigorous, but for many other larger integers concerning which this verification is impossible? And if such be the case, is it not one of those discontinuous phenomena whose explanation requires a very large number of parameters? It does not seem so: on the one hand, the formula with the variable integer contains in fact but a small number of constants; on the other hand, the attempts made for explaining the presence of this integer by hypotheses of physical discontinuity have led to the placing of this discontinuity within the atom itself; there is consequently no need of a very large number of atoms: one alone is sufficient, whose structure depends only on certain parameters, on *magnétons* in the theory of Ritz, parameters the number of which is far from being of the same order as the number of the atoms.

This remark leads us to consider another category of phenomena, to which we have already alluded, and in which the atoms or corpuscles are observed individually. Does not the explanation of these phenomena require atomic hypotheses? It seems difficult to deny it without being paradoxical. Let us note, however, that such phenomena as the emission of the α particles are susceptible only of a globate explanation; it is not possible to foresee with accuracy any particular emission, but only a mean number; scientifically speaking, therefore, this mean number alone has any existence; the phenomenon which consists in the emission of one α particle does not present the characters which permit of rigorous experimentation: one cannot either foresee it or reproduce it at will; it is only the study of the trajectory *after* the emission that offers these characters; and in fact this study requires only such a limited number of equations that one can write them all. The atomic hypotheses would enable us to foresee each individual emission, if one could in fact calculate with reference to an extremely great number of equations; but that is not possible, and so far as the *globate* prevision is concerned the atomic hypothesis is not, at least *a priori*, necessary.

We touch here upon the borders of science, since we reach phenomena accessible to our observation, and which depend upon causes too numerous for us ever to know them with precision in their full complexity. Science remains possible only for mean values which can be calculated with precision by means of data accessible to observation.

It is well understood, I hope, that I do not dispute the legitimacy and usefulness of molecular theories; my remarks as a mathematician cannot attain physical reality; at the bottom, they do not go farther than this: all the calculations we shall ever be able really to effect will comprise only a rather limited number of equations actually written; if we

write one equation, and if we add that we consider several billions of analogous equations, we do not, in fact, calculate these unwritten equations, but only the written equation, taking into account perhaps the number of these unwritten equations, a number which also has been written. Every mathematical theory, therefore, reduces itself to a relatively small number of equations and calculations, which involve a relatively small number of symbols and numerical constants; it is therefore not absurd *a priori* to suppose that one might conceive a physical model containing also a relatively small number of parameters and leading to the same equations. As long, however, as this model has not been imagined—and perhaps it will never be—the analytical or geometrical researches on functions of a very large but finite number of variables will offer some interest for the physicists.

VI

We have already observed that it is an ordinary proceeding in mathematics to replace a very large finite by an infinite. What result does this method yield when it is applied to physically discontinuous phenomena, whose complexity seems bound up with the very large number of molecules? Such, for instance, are the phenomena of the Brownian movement, which is observed when very fine particles are in suspension in an apparently quiet liquid. These phenomena fall within the category of those we were mentioning a moment ago, of which none but a statistical foreknowledge is possible.

Is it possible to construct an analytical image of such phenomena? Professor Jean Perrin[1] has already called attention to the fact that the trajectories observed in the Brownian

[1] Jean Perrin, "La discontinuité de la matière," *Revue du Mois*, mars 1906. See also Jean Perrin, "Les Atomes," Alcan 1913.

movement suggest the notion of continuous functions possessing no derivatives, or that of continuous curves possessing no tangent. If one observes these trajectories with optical instruments of increasing perfection, one sees, at each new magnification, new details, the curvilinear arc that we could have traced being replaced by a sort of broken line the sides of which form a finite angle with each other; this remains the case up to the limit of the magnifications at present possible. If we admit that the movement is produced by the impact of molecules against the particle, we must conclude that, with a sufficient magnifying power, we should obtain the exact form of trajectory, which would present itself under the form of a broken line with rounded angles, and which would not be perceptibly modified by a still further magnification.

But the analyst is not forbidden to put off indefinitely in his thought the realization of this final state, and thus to arrive at the conception of a curve in which the sinuosities become finer and finer as one uses a higher magnification, without ever obtaining the final sinuosities: this is indeed the geometrical image of a continuous function not admitting of a derivative.

We obtain also a curve of a similar nature, sufficiently interesting to arrest our attention, when we study the function which Boltzmann designates by H and Gibbs by η, and which represents, in the case of a gas, the logarithm of the probability of a determinate distribution of the velocities of the molecules. Each collision between two molecules gives a sudden variation to this function, which is thus represented by a staircase curve, the horizontal projections of the steps corresponding to the intervals of time which separate two collisions, the number of the collisions undergone by a molecule being some billions per second (that is to say, of the

order of magnitude 10^9), and the number of molecules of the order of magnitude 10^{24} (if we consider a mass of a few grams of gas), the *total* number of collisions per second is of the order of magnitude 10^{33}; such is the number of steps projected on a portion of the axis of the abscissæ equal to unity, if the second is taken as the unit of time.[1] What the physicists consider is the mean behavior of the curve. They replace the serrated curve by a more regular curve having the same mean behavior in the time intervals, which are very small in comparison to the second, but very great in comparison to 10^{-33} of a second.

These diverse considerations bring interesting suggestions to the analyst, on which I should like to dwell for a moment.

In the first place, referring to the continuous curves without derivatives of which the Brownian movement has given us the image, should the passage from the finite to the infinite lead to a curve *all* of whose points are points of discontinuity, or to a curve which admits an infinitude of points of discontinuity, but also an infinitude of points of continuity? For a proper understanding of the question, it is necessary briefly to recall the capital distinction between denumerable infinity and continuous infinity. An infinite ensemble is said to be denumerable if its terms can be numbered by means of integers. Such is the case for the ensemble composed of terms of a simple or multiple series; we can also cite as a denumerable ensemble the ensemble of the rational numbers. On the other hand, the ensemble of all the numbers comprised between 0 and 1, both commensurable and incommensurable, is not denumerable: we say that this ensemble has the same power as the *continuum*. If we define a discontinuous func-

[1] This discontinuity supposes evidently that we consider the duration of a collision as less than the mean interval of two collisions (in the whole mass), a hypothesis difficult to admit. The *schema* to which this hypothesis leads is not less interesting from the analytical point of view.

tion by a series each term of which admits a point of discontinuity, the ensemble of these points of discontinuity is denumerable, as are the terms themselves. Can we determine a function which shall be totally discontinuous—that is to say, one whose points of discontinuity shall be all the points of a continuous ensemble, and not merely those of a denumerable ensemble? It would seem to be easy to imagine such a function. Such is the oft-studied function which is equal to 1 if x is commensurable and to x if x is incommensurable; this function is indeed discontinuous, as much so for the commensurable values as for the incommensurable values. If we look a little closer, we perceive that the discontinuity is not the same in these points: we must note, in fact, that the commensurable numbers occupy infinitely less space in the axis of the x's than do the incommensurable numbers; the ensemble of these commensurable numbers is of dimension zero—that is to say, it can be confined within intervals whose total extent is less than any number given in advance. Speaking in more concrete terms, if we choose a number at random, the probability that it will be commensurable is equal to zero.[1] We therefore conclude that the function equal to x for the incommensurable values of the variable is, *on an average*, continuous for these incommensurable values, whatever its values may be for the commensurable values—that is to say, if we choose in the neighborhood of an incommensurable value, for which we study the continuity, another value *taken at random*, it is infinitely probable that this value taken at random will also be incommensurable; it is then infinitely probable that the variation of the function will be infinitely small when the variation of the variable is small.

[1] To give one's self a number at random, one may agree to choose at random the successive figures of the decimal fraction which is equal to it; the probability that this decimal fraction will be finite or periodic is evidently equal to zero.

This remark enables us to understand that it has not been found possible to define analytically a function all the points of which are effectively points of total discontinuity; it is only in points determined according to the definition of the function, and playing a particular part in this definition, that the function is actually discontinuous on an average.

The passing from the finite to the infinite, when we are concerned with the discontinuity of functions, is, then, not effected after the manner which is most usual in classical mathematical physics, in which matter is supposed to be continuous, and in which the finite is replaced by the continuous; we are led to conceive a different process, which seems, besides, more in harmony with the molecular conception, and which consists in replacing the very great finite by the denumerable infinite.

This is the way in which the analytical generalization of such curves as the H curves presents itself from this point of view. Let us consider a number written in the form of an interminate decimal fraction, and let us imagine that the figures which follow the decimal point are grouped in successive periods, each period containing many more figures than the preceding period. To each period we shall cause to correspond one term of a series, this term being equal to zero if in the corresponding period the ratio of the number of even figures to the number of odd figures is comprised between 0.4 and 0.6; while if this ratio is not comprised between these limits, the term corresponding to the period is equal to the term of the same order of a certain convergent series with positive terms. It is clear that, if the lengths of the successive periods increase rapidly, it is infinitely probable that a small number of periods only will furnish terms different from zero; consequently, the series which corresponds to the decimal number will be terminate; this termi-

nate series has a certain sum, which remains the same as long as the decimal number varies so little that the last one of the periods which gave a term to the series is not modified; at least in the interval thus defined it is extremely probable that the function corresponding to the decimal number preserves this constant and well determined value—that is to say, is represented by a horizontal line; however, there are in this interval, as in every interval, particular decimal numbers for which certain periods of high order, perhaps even an infinitude of such periods, are irregular from the point of view of the distribution of even and odd figures; there are then intervals which are extremely small, and, on an average, extremely rare, but nevertheless dense everywhere, in which the curve runs up above the horizontal line which in general represents it. In one of these points, which we may call maxima of the curve, it is extremely probable that, if we take a value in the neighborhood of the variable at random, the function will diminish—that is to say, that this point has, on an average, the character of a maximum in a point.

In the preceding example the maxima are represented by intervals narrower and narrower, but finite; in modifying slightly the definition, one can obtain a curve which would coincide everywhere with the axis of x, except in points not filling any interval; it is sufficient to agree that, in the series which we have just defined, we replace by zero every term which is followed by an infinitude of terms equal to zero; the new series can then be different from zero only if the terms of the first series are all, after a certain place, different from zero.

The study of analytical models thus obtained leads us to go deeper into the theory of functions of real variables, and even to conceive new notions such as the notion of *average derivative,* naturally suggested by the physical example of

the function H.[1] Besides, it is necessary to observe that in the study of these functions the notion of continuous ensemble is often combined with the notion of denumerable ensemble; for example, it is easy to see that the ensemble of decimal numbers whose figures are all odd presents certain characters of the ensemble of all the decimal numbers; it has, as we say, the same power as the continuum,[2] but it is, however, of zero dimension.

We may also connect with these considerations the theory of denumerable probabilities—that is to say, the study of probabilities in the case in which either the infinitude of trials or the infinitude of possible cases is denumerable—a study lying between the study of probabilities in the finite cases and the study of continuous probabilities.

VII

In spite of the interest of problems relating to functions of a real variable, it is the theory of functions of a complex variable which, since the immortal discoveries of Cauchy, is really the center of analysis. The analogy between the theory of the functions which Cauchy has called monogenic functions and which are often called analytical functions, and the theory of Laplace's equation which is verified by potentials, is undoubtedly one of the most fruitful analogies in analysis. We know all the advantage Riemann has derived from the theory of potential and from physical intuition in his profound researches upon the functions of a complex variable.

[1] Emile Borel, "Comptes Rendus de l'Académie des Sciences de Paris," 29 avril 1912.

[2] If in a decimal number all of whose figures are odd we replace the respective figures 1, 3, 5, 7, 9 by the figures 0, 2, 3, 4, we may consider that number as any number whatever written in the system whose base is 5.

It is therefore natural to ask one's self what new ideas can be brought by molecular theories into this domain of complex variables. Here again we shall be led to replace the very large finite number by the denumerable infinity: it is easy to form series each term of which presents a singular point, the ensemble of the terms of the series thus possessing a denumerable infinitude of singular points. These singular points may, for instance, be so chosen that they coincide with all such points among the points inside of a square whose two coördinates are rational. The most simple series that we can thus form presents itself under the form of the sum of a series of fractions each of which admits of only one pole, which is a simple pole. The physical interpretation, in the domain of reality, of such a series leads us to consider the potential of a system composed of an infinitude of isolated points, the mass concentrated in each of these points being finite (which leads us to admit that the density in each such point is infinite, if the point is considered abstractly as a simple geometrical point without dimensions). We suppose, of course, that the series whose terms denote the values of the masses is convergent, which amounts to saying that the total mass is finite, although concentrated in an infinitude of distinct points—for example, in all the points whose two coördinates are rational numbers.

The potential with which we are now concerned is in the case of a plane what we call a logarithmic potential; we could reason similarly in three-dimensional space: we should then have the Newtonian potential properly so called.

The hypothesis that the attracting masses are simple material points without dimensions is difficult to accept from the physical point of view; one is thus led to perform the analytical operation which consists in dispersing this mass into a small circle (or a small sphere) having this point for

center, without changing the potential outside of this circle (or sphere); we shall call this circle (or sphere) the "sphere of action" of the point which coincides with its center; we shall choose its radius to be proportional to the mass concentrated at its center, so that, if the series formed by the masses converges with sufficient rapidity, we may arrange things in such a manner that the radii of the spheres of action also form a very rapidly converging series, and yet that the maximum density of the attracting mass be finite. It is also easy, if we admit that we can dispose arbitrarily of the distribution of masses and densities, to arrange things in such a way that the distribution in each sphere of action, as well as its derivatives, is reduced to zero over the whole surface of the sphere; the distribution of the density is thus not merely finite, but continuous throughout space.

The hypothesis which we have made concerning the convergence of the series the terms of which are the radii of the spheres of action, implies the convergence of the series the terms of which are the projections of these spheres on any straight line whatever; if, therefore, in this series, we suppress a certain number of the first term, the rest of the series can be made less than any number fixed in advance. From this we conclude that in an interval, however small it may be, taken on the straight line on which we project the spheres, we can find an infinite number of points which belong at the most to a finite number of such projections—namely, those belonging to the spheres S which correspond to the first terms of the series, and which were suppressed in the series in order to make the remainder less than the interval considered. If we consider a plane perpendicular to the straight line and passing through one of these points (this point being chosen, as is possible, distinct from the projections of the

centers of the spheres S, finite in number, concerning which we have just spoken), this plane will at most intersect a finite number of spheres S, without going through their centers, but will be exterior to all the other spheres of action. It is possible to modify the distribution of matter within the spheres S which are finite in number and intersected by the plane in such a manner as to replace these spheres by smaller ones which do not intersect the plane, this operation not modifying the potential outside of the spheres, and the density remaining finite, since the operation relates to only a limited number of spheres. To sum up, it is possible to find a plane perpendicular to any straight line whatever, cutting out of this line any segment whatever given in advance, and such that in all the points of this plane the density shall be zero. Since our potential function is defined by a density everywhere finite and continuous, this potential satisfies the equation of Poisson, which reduces itself to the equation of Laplace wherever the density is zero—that is to say, in all the points of the planes which we have just defined. It was not idle to insist upon this point, for these planes may traverse regions of space in which the given material points are everywhere dense—as are, for example, all the points whose coördinates are rational numbers. We might have feared that there would be no free space between points so closely pressed together, so to speak; we have just seen that this fear was unjustified. The theorem of the theory of ensembles which is necessary and sufficient for demonstrating this result in a rigorous manner is the following: *If on a segment of a straight line we have an infinite number of partial segments (in this particular case, the projections of the spheres of action) whose total length is less than the length of the segment, there exist on that segment an infinite number of points which do not pertain to any of the partial seg-*

ments. This formulation is almost self-evident, and besides, it would be easy to demonstrate it rigorously.

In the case of the plane we shall replace the spheres by circles and the plane perpendicular at a point of the segment by a perpendicular straight line; we can easily prove that, even in the region where the singular points are everywhere dense, there are points at which an infinite number of such lines intersect, on which the density is zero; at these points the logarithmic potential function satisfies Laplace's equation in two variables. If we study in a similar way the function of a complex variable with poles dense in one region, we define an infinite number of straight lines of continuity, intersecting in all directions, the function admitting of derivatives which are continuous on these lines, and the derivative having the same value in all the directions in each of the points of intersection. To express this fact we shall use the word created by Cauchy for designating functions which admit of a derivative independent of the argument of the increment of the variable; these functions may be called monogenic, but they are not analytical, if we reserve for the word "analytical" the very definite meaning which it has possessed since the labors of Weierstrass.

Without lingering on the physical analogies suggested by the existence of planes which do not intersect the spheres of action of the attracting masses, I should like to insist a little upon the nature of the mathematical problems arising out of the existence of these monogenic but not analytical functions. We know that the essential property of analytical functions is that they are determinate in the whole domain of their existence, when their values are given in one portion, however small it may be, of that domain. Is that property a consequence of analyticity—that is to say, of the existence of the Taylor series with radius of convergence differing from zero

—or of monogeneity—that is to say, of the existence of the unique derivative? This question was meaningless as long as it was possible to confound analyticity with monogeneity; on the other hand, it takes a verv clear signification as soon as we have succeeded in constructing non-analytical monogenic functions.

I cannot enter to-day into the detail of the deductions which have led to the solution of this problem;[1] here is the result: it is, indeed, monogeneity which is the essential character to which the fundamental property of analytical functions is due; this fundamental property subsists for the non-analytical monogenic functions as soon as we specify clearly the nature of the domains in which these functions are considered. I have proposed to call the domains satisfying these distinct conditions "domains of Cauchy." A domain of Cauchy is obtained by cutting off from a continuous domain domains of exclusion analogous to the spheres of action just mentioned, domains which may be infinite in number, but whose sum can be supposed to be less than any given number (just as the spheres or circles of exclusion just considered, whose radii once chosen we can multiply by any number less than unity, while we are free to increase the upper limit of the density at the same time as we decrease the radii of exclusion).

The series formed by these excluded domains should, evidently, be supposed to be convergent; moreover, we ought to suppose that its convergence is more rapid than that of a determinate series which it is not necessary to write here. Under these conditions, which refer only to the domain and not to the function, every function which in Cauchy's domain

[1] See Emile Borel, "Définition et domaine d'existence des fonctions monogènes uniformes" (*Journal of the International Congress of Mathematicians*, Cambridge, England, 1912); "Les fonctions monogènes non-analytiques" (*Bulletin de la Société Mathématique de France*, 1912).

satisfies the fundamental equation of monogeneity possesses the essential property of the analytical function; we can calculate it throughout its domain of existence by the knowledge of its derivatives at one point (the existence of the first derivative involves the existence of all the derivatives, at least in a certain domain which forms part of the Cauchy domain), and this mode of calculation implies the consequence that, if the monogenic function be zero on an arc however small, it is zero in every point of the domain of Cauchy: two functions, therefore, cannot coincide on an arc without coinciding throughout their domain of existence, in the generalized sense.

I cannot develop the consequences of these results from the point of view of the theory of functions; but I should like, in closing, to submit to you some reflections which they suggest concerning the relations between mathematical and physical continuity.

VIII

Most of the equations into which we translate the physical phenomena have certain properties of continuity; the solutions vary in a continuous manner, at least during a certain interval, greater or less in length, when the given quantities vary in a continuous manner. Besides, this property is not absolutely general, and it might happen that the theories of the *quanta* of emission or absorption may lead us to give more importance than heretofore to exceptional cases; but to-day I do not wish to enter upon this discussion; I limit myself to the general property, verified in a large number of cases.

When we seek to interpret this property in the theory of the potential and of the monogenic functions, we should expect, if for simplification we confine ourselves to the real functions of a single variable, to find a sort of continuous

passage between such of these functions as are analytical in the Weierstrassian sense and those which are entirely discontinuous. Now, this is precisely what does not occur unless we consider non-analytical monogenic functions; as soon as a function ceases to be analytical it no longer possesses any of the essential properties of analytical functions: the discontinuity is sudden. The new monogenic functions permit one to define functions of real variables which might be called quasi-analytical and which constitute in some way a zone of transition between the classical analytical functions and the functions which are not determined by the knowledge of their derivatives in a point. This transitional zone deserves to be studied: it is oftentimes the study of hybrid forms which best teaches us about certain properties of clearly defined species.

We see that the points of contact between molecular physics and mathematics are numerous: I have only been able to point out, in a rapid manner, the most important among them. I am not competent to ask whether the physicists will be able to derive immediate advantage from these analogies; but I am convinced that mathematicians can only gain by investigating them more thoroughly. Mathematical analysis has ever been rejuvenated by contact with nature; it is only because of this permanent contact that it has been able to escape the danger of becoming a pure symbolism, revolving in a circle about itself; thanks to molecular physics, the speculations on discontinuity will assume their full significance, and will develop in a truly fruitful manner. And while it is impossible to foresee the exact applications of these researches, it is not unlikely that the mental habits they foster will not prove useless to those who desire to undertake the task, that cannot long be deferred, of creating an analysis adapted to theoretical researches in the physics of discontinuity.

EMILE BOREL.

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PHILOSOPHICAL LANDMARKS

BEING A SURVEY OF THE RECENT GAINS AND THE PRESENT PROBLEMS OF REFLECTIVE THOUGHT[1]

LECTURE I

WHEN John Milton wrote the "Areopagitica" and predicted the future greatness of the English people, that people had staked its life upon its liberty, and was in danger of losing it. It was in the midst of the unspeakable disasters of civil war. During the centuries which have succeeded Milton's day the English nation has never ceased to struggle against obstructions without and obstacles within. It is a nation tried to its uttermost. But, on the whole, and to an extent which is rare in human affairs, its history has verified the vision of the poet. Its prosperity in all matters of lasting worth has been very great. It has borne well the weight of its responsibilities, and, in spite of imperfections, it has so fulfilled its mission to mankind that though England, like Israel, Greece, and Rome, were now to perish, it would, like them, remain for the human race a precious possession forever.

It may be profitable for you, whose nationality has also "been welded not in peace but in the storm of battle," to inquire what was the ground of the poet's assured confidence in his country. What evidence lay there and then before him which would justify his trust in the destiny of his people? In its circumstances there was none, for these were

[1] Three lectures presented at the inauguration of the Rice Institute, by Sir Henry Jones, Professor of Moral Philosophy in the University of Glasgow, and Hibbert Lecturer on Metaphysics at Manchester College, Oxford.

untoward to the last degree. It had neither wealth of material resources, nor greatness of population, nor weight of armaments, nor vast extent of territory. It was a small and a poor people, without great traditions or high rank among the nations, and inhabiting a portion of a little island. Yet, with rarely paralleled political pride, Milton called upon "the Lords and Commons of England to consider what Nation it was whereof they were, and whereof they were governors," so that they might match the greatness of their trust. In doing so, he referred solely to the intrinsic character of the people, and indeed to one element therein. He found them "a nation pliant and prone to knowledge." They "prized the liberty to know, to utter and to argue freely according to conscience, above all liberties." It was only on this ground that the nation seemed to the poet to be "like an eagle renewing her mighty youth." In his sight she was first among the nations of his time, because she was first in her love of truth; therefore was "she destined to be great and honourable in these later ages."

From one point of view we may say that there was nothing new in Milton's attitude. The truth to which he gave such stately expression is, in fact, a truism. It is as old as man's first reflection upon his own destiny. Homer teaches it when he makes the Greeks advance to battle in ordered and silent ranks, under wise commanders inspired by Athena, while the Trojans stream out in a confused and shouting mob, driven forward by Ares, the god who is the embodiment of animal ferocity and passion. This is the conviction of the wise in "all generations": that if there be any law in human affairs or any continuity in their confused history, it is that which dwells in man's own soul and secures the victory of the ordering intelligence and the disciplined will over the blind forces that operate in his world.

But from another point of view the attitude of Milton may be called unique and even surprising. Stern moralist as he was, and a spirit which was devoted to the service of the Highest, we should have expected him to dwell first upon the ethical or the religious conditions of a nation's welfare. But it is its "proneness and pliancy to knowledge," and the store it set upon the liberty to know, to which he assigns the highest value and the first importance.

Had he lived in our day, we should have reduced the significance of his mission and called him an "intellectualist"; for we are prone to prize faith in some domains, and practice in others, above knowledge, and to regard "truth" as mere means to a further good. I believe, however, that Milton spoke well and wisely. "The liberty to know" *is* in fact greater than all other liberties; for it is their condition. Man cannot enter into his inheritance, whether that inheritance be natural or spiritual, except through this door. As the beauty of the natural scene is there only to the seeing eye, so the utilities of Nature's forces and the treasury of her resources are open only to him who can comprehend them; and the obligations which are also the opportunities of man's moral achievement exist only for him who adopts them as the convictions of his own mind and the purposes of his own will. Efficient practice, whether on the minutest or on the widest scale, rests upon clear and relevant knowledge. It is as necessary to the artisan in handling his tools as it is to a statesman guiding the affairs of a nation. The fact which is not comprehended is an outer necessity which limits man's freedom, frustrating his intelligence and obstructing his will. The discoveries and inventions of modern science in all their wide range, and man's whole progress in civilization, bear witness to this truth: it is the intelligence of man which alone

can emancipate him. His charter of freedom is inscribed in her own soul.

Now it is the main characteristic of our time that it has, at least in one great department, laid this lesson well to heart. We consider no labor too severe or continued, no equipment too costly, which promises, by means of the natural sciences, to secure more intimate communion between the reason of man and the reason which is embedded in the physical order. It is only in this way that we can bring its powers to our will. We have learned that the iron-hearted mechanism of nature, which were it not for man's rational endowment would entangle him in its vast scheme, can by means of his understanding of it be changed into the rich possession of his mind and the instrument of his will. Its unchangeable and inexorable laws, seized by way of their meaning, are made to minister to his purposes and to express his spontaneity. By means of knowledge man stands a sovereign among the natural powers, and he is free, not in their despite, but by their help, for they enlarge the scope of his effective will.

This, indeed, is the ultimate and by far the most significant consequence of man's intelligent converse with the outer world, the greatest of all the gifts of the natural sciences to mankind. But it is not that which has attracted our attention. As a rule, we trace the influence of the theoretical discoveries of science no further than the practical inventions in which they result; and if we discern, we do not reflectively consider, the manner in which they recoil upon man himself. The achievement upon which in this age we justly pride ourselves is the interpretation of Nature's laws, and our consequent sway over her energies. We seek little more, and we look no further, as a rule. We forget that it is the indirect, the remote, the unexpected and unsought consequences of man's actions which mean most. It is a law of his life, and a

symbol of the generosity of the scheme within which he lives, that he always builds more wisely than he knows. He is guided unconsciously as by an architectonic mind, which comprehends him and his environment, and whose purposes he cannot guess until he beholds them accomplished.

It is my purpose to call your attention to this aspect of the scientific enterprise which you are so auspiciously inaugurating here to-day. I would fain indicate the manner in which the natural sciences, for which you are making your most generous provision, must not only extend your mastery over the outer world, but reverberate within your inner selves, enriching and enlarging the powers of your rational nature.

When man's thought sets free the forces of the open world, these take up his deeds and carry them forward to issues which he cannot clearly foresee, and yet which he dare not leave unconsidered. For these also yield their best gifts only to the spirit which can at once obey and control them; and neither the obedience nor the control is possible except in the measure in which they are comprehended.

This consequence is seen to follow the moment we discern what takes place when man acquires knowledge of any object. It is that the nature of mind is itself exhibited in the process. He cannot enter into closer communion with the natural world by means of the sciences without at the same time both manifesting and realizing the powers of his own soul. Mind, like every other form of energy, natural and spiritual, shows what it is in what it does. It exhibits itself in its operations. It is by matching his intellectual power against the world and forcing its obdurate facts to yield their meaning that he reveals the splendor of his rational endowment. Could we have known the potencies which slumber within him, if we could have known his mind and his ways of life when the phenomena of nature, instead of being open to

his thought and subservient to his will, were nothing more than objects of fear and wonder? Or is it not true, rather, that the process by which he has gradually withdrawn the veil from the face of nature and brought to light order among its contingencies, is the same in its other and great aspect as the process of the self-revelation of his own spirit? For knowledge comes neither from mind nor from its object, but from both. It is neither *a posteriori* nor *a priori*, because it is both the one and the other, and that always. Truth is neither unveiled by man, nor is it given to him ready-made. It is, in every item of it, the result of the interaction of mind and its object. Light springs from the impact of spirit and nature. Nay, as we shall see more fully hereafter, these imply each other, they are elements in one scheme, opposed but complementary aspects of the one reality. And it is only in their unity that they have significance, value, or use.

I do not anticipate any contradiction when I say that the greatest and by far the most significant of all the consequences of man's triumphant progress in his comprehension of the physical cosmos is the light which that process has thrown upon man himself. But its full meaning can be seen only when we consider another and a still remoter consequence. Man's more intimate communion with nature by means of natural science has brought him into closer communion with his fellows. Seeking no such end, the sciences have made men, throughout the civilized world, members of one another. They have broken down man's isolation, refuted his egoism even when it leaves him selfish, made him independent whether they will or no, welded their interests together, and constituted them into organs of a vast whole to which they give and from which they borrow all the elements of their larger life. Within it they find their in-

dividual functions; and, seeking their own ends, they nevertheless constitute a vast, complex, and single whole whose elements collaborate even when they conflict, and whose power for all human purposes no man can measure.

The first revelation of the potencies which slumbered in man's spirit was made when the reason within him succeeded in holding rational communion with the reason that is embedded in the physical cosmos. But this second revelation is greater. We can see his powers in the fullness of their might when he is thus united in one scheme with his fellows, and spirit communes face to face with spirit. Then is the range of his personality in truth extended, and the reach of his mind and will. The blacksmith at his forge, like the thinker in his study, is seen to serve and to be served by the interchanging enterprises of the general mind of his times. For it is no flight of rhetoric, but the simple truth, to say that our interests now are cosmopolitan. This is illustrated in the common ways of our daily life: in the food we eat, the clothes we wear, and the tools we use. The same change which has passed over the face of nature has passed over the spirit of man. Science is translating facts into instances of universal laws. It is tearing facts out of their seeming isolation. It is revealing them as temporary resting-places of unresting energies, momentary combinations of forces which have come from the beginning of things and are moving onward on an endless way. Nature is no longer an aggregate of disconnected facts, or the scene of contingent happenings. It is the realm of concrete universal laws. These have not supplanted the facts, it is true, nor arrested the happenings; but they have illumined them, showing that they are the mere foci of the world's unresting energies.

But the universal in nature is at once the offspring and the parent of the universal in man; so that he too, by the indirect

influence of the sciences, is being reinterpreted and regenerated. Man remains, it is true, and must remain, a unique personality. To the end he will maintain his subjective integrity and inviolable privacy; he will look upon the wide world through his own most individual thought, and act upon it from the secret depths of his own most exclusive will. But the thought and the will which are his own and exclusive are capable of a wide comprehension. He is also being revealed as an individuated organ of a vast whole. He is the intense because the self-conscious focus of the meaning and the use of the world. He is a pulse-throb of a universal mind which sustains the natural order, and operates in him, through him, by him, and, I believe, for him. And this discovery, it seems to me, is the crowning achievement of the modern age. Its interest in the meaning of the outer world, and the consequent conversion of its forces into man's ministrants, have, without man's knowledge or purposed seeking, begun the integration of humanity, and set it forth on an adventure more generous in its promise than he can compass by his freest thoughts.

Now it has seemed to me that if a votary of philosophy has any mission among you to-day, it is to invite your attention for a little to this vaster and remoter realm of the consequences of devoting your thoughts in this institution to the discovery of nature's secrets. For every truth attained breaks out into a new problem demanding a new solution; every practical achievement brings into it a new task; and every goal of spirit is a point of departure on new adventures. And it is the peculiar task of philosophy to suggest to the minds of men the regions not yet conquered and the inheritance not yet gained and secured.

The main outlines of our next adventure are becoming obvious. It is to comprehend the laws according to which

this new world of the interconnected wills of men must operate. The demand for knowledge—for knowledge that is systematic, tried, and secure—of this world of man is already felt to be urgent in some directions. I presume that there is no maker or seller of material things among you who does not know that if he is to secure his own economical well-being, he must know something of the world's mind and be able to interpret and anticipate its wants. This problem is infinitely more complex, and the risks of error are incalculably greater than they were when human society consisted of small, isolated, simple, self-centered and self-supporting units. His success or his failure in his business enterprises comes upon him from the ends of the world, and he must widen the range of his purposes.

But what applies to the economic phase of our modern life applies in like manner to *all* its elements. Control can come only by the way of comprehension, and forces which we do not understand are inexhaustible sources of risks and surprises. And who comprehends the social forces of these times? All the civilized nations of the world exhibit the same phenomena. We have emancipated the people; we have awakened their sense of their rights; we have multiplied their wants and extended the range of their desires; and, in one word, we have ushered in what we can hardly do more than name and fear—namely, Democracy. It is a thing which is to be its own law; it is to walk in the light of its own convictions; it is to map out the lines of its own welfare; it is to repudiate every authority, political, moral, or religious, which wears a despotic face; it must issue its own imperatives, and every appeal is to itself alone.

The greatest discovery ever made by man was made by the Greeks when, cutting themselves free from the traditions of the ancient world, they alighted upon the conception of a

civil state where citizens should be free. The most momentous experiment of mankind is that of carrying out their conception to its ultimate consequence in a true democracy. But that experiment, conducted among the elemental powers of man's world and involving all the major issues of his welfare, is carried on in the bewildering twilight of mere opinion. First, appearances are taken for facts; there is little inquiry, and there is less logic or method. The democracies of the world, guided by no prophetic seer and possessing little light of their own, are stumbling along an untried and unknown way to an unimagined goal. They are convinced of their illusions only by suffering their consequences, and they discover the truth only by exhausting the possibilities of error. It is a costly method and an insecure one. Universal unrest verging constantly toward conflict characterizes all their ways.

I do not think that we can trust this method much longer. The need for self-comprehension is becoming urgent. The risks of ignoring the problems of the general life of man are growing greater as the democracies wax in magnitude and strength, assert themselves with less and less reserve, and are less and less patient of restraint. And, moreover, a fundamental discrepancy has arisen between the inner or self-conscious life of recent times and its outward circumstances. Man's knowledge and control of himself have fallen out of step with his knowledge and control of his physical environment. In the case of the latter the boundaries of the nations are overleapt and the exclusiveness of their individualism is multiplied. Scientific knowledge and inventions and the vast economic resources which issue from them are objects of cosmopolitan interchange. But our ethical temperament has received no such enlargement or emancipation, and is still narrow and class-tainted and parochial. And this dis-

crepancy will bring its penalties. Have you ever known any instance of incongruence between the inner and outer conditions of a nation's life which has not been fraught with peril? It is this cause which divides a nation against itself and constrains it to have recourse to the violent remedy of revolution. A reinterpreted world is a reconstructed world. It propounds new problems for man. And they are like the riddles of the Sphinx: they must be answered on pain of death; they have no answer except Man himself.

Surveying the modern situation as a whole, what is it, then, that we see? It is the vast extent of the domain which the physical sciences have conquered within so brief a period of the history of the human race that it seems but the hour of the dawn; the great army of explorers in every civilized land, equipped with every instrument which can aid their search, who are year by year and almost day by day pressing its boundaries further; the growing marvel of the practical inventions which follow hard upon the theoretic discoveries; the utilities, latent from the beginning of time in the structure of the physical world, which these inventions are setting free; and, on the other hand, the inexhaustible variety and unconfined range of man's wants and desires which all these things have called into existence, and which are clamorous for satisfaction; the complex, restless, tumultuous, and yet unruled world of industry and commerce which has been welded together and is designed to meet these wants; the consequent integration of mankind into organized communities; the rise of the great order of national, political states which are themselves but organs of a still wider humanity, all of them from time to time disturbed and occasionally well-nigh distraught by the economic and social collisions of their elements. Such are the results which we must attribute mainly to the devotion and the triumphant progress of modern

science. Guided and inspired by them, the multitudinous activities of individual minds and wills, each of them permanently set upon its own personal ends, have put together a vast social structure with almost as little conscious purpose as that which guides the coral insects building their reefs amid the ocean's waves. That structure has its own laws of being and ways of operating, and these are as remorseless as the laws of the physical cosmos. But I believe that they are as beneficent, too, provided they are understood. How, then, can we doubt that man must fit himself for this new world which he has called into being, or that in order to do so he must go forth on a new adventure? It is not only that of comprehending the physical world and employing its energies, but of comprehending the master-power which is the cause of the great change. Side by side with the sciences of Nature, the sciences of man must arise. Man must come back to himself, contemplating the mystery of his own spirit, for in it is the key of the final enigma of the world.

But this is the specific venture of Philosophy, and Philosophy has fallen into disrepute. So scanty has been the harvest of her long toil, as compared with that which the natural sciences have brought triumphantly home, that the general mind of the modern age would turn away from her. Philosophy, the mother of all the sciences, has now to plead, and even at times to plead in vain, for permission to erect a humble lodge among the mansions of her daughters. We would prize her gifts beyond all others, could she but bring them within our reach. But we despair of her powers. Even the incomplete, tentative, errant, but slowly progressive interpretation which man alone can give of any object, seems to be impossible for us when our problem is Man. An obstacle lies across the very threshold of this, the most urgent as well

as the greatest of man's spiritual enterprises: it is his diffidence when face to face with the mystery of his own being.

And, in truth, the mystery is very great. Even his physical structure is revealed by science to be the consummation and the most complex epitome of the cosmic scheme, and all its problems converge in him. And his soul, his mind, his spirit is the self-conscious counterpart of all his world. He is its expression, in him brute force emerges into meaning, and its reality takes upon itself the form of truth. The complexity of the problem is infinite, and the consciousness of its magnitude paralyzes the inquiry of philosophy.

Moreover, when we are dealing with spirit and its manifestations in any one of the arts or sciences, or in the most complex social world in which all these are sustained, the method which has been so successful in the investigation of the facts of the outer world cannot be employed, except at the greatest risk and under constant correction. The natural sciences can, without much violence to their object, distinguish and even isolate its aspects and deal with them separately. But when we leave the physical sphere, where relations are relatively external and contingent, and ascend stage by stage along the internal relations of organic life to the intense unity of self-consciousness, in which all differences are at once sustained and overcome, abstraction becomes more and more misleading. There every element depends for its being, function, and meaning upon the whole system of which it is a part. The problem of the whole comes upon us everywhere, and it seems impossible to attain any truth without grasping it in its totality.

It follows that philosophy has no more right to be abstract than a work of art, or to be fragmentary than religious faith. Even the pragmatist, whose main mission seems to be to maintain that the world is, at least in part, the

playground of contingencies, must make the apparently preposterous claim of pronouncing upon its final nature and grasping it as a whole. He also is "a spectator of all time and all existence," and its condemning judge.

And it follows that even as an outline the philosopher's version of the universe of reality must fail, and fail in every way. Its principles are mere hypotheses, and nothing is fully demonstrated. The application of the hypotheses to facts is incomplete on every side; they retain their secrets, remain enigmatic, and they seem to conflict with one another and with the system as a whole. And the failure of philosophy, which we might well prognosticate from the magnitude of its task, seems to be more than indorsed by its troubled and apparently futile history. We are driven to think that the enterprise exceeds our powers, that there is no resource in reason, and that the philosopher must take his seat among humble men, and say, like them,

I stretch lame hands of faith and grope,
And gather dust and chaff, and call
To what I feel is Lord of all,
And faintly trust the larger hope.

And man cannot set aside the enigma. He must persist in the attempt. But the question arises, Why do men persist in the attempt? And the wisest of men, why do they not turn aside from the vast inquiry and "cultivate their gardens"? Can it be that it is impossible for them to do so without violating their own rational nature? Is there some necessity either in man himself, or in the nature of things, or in both, which he cannot escape, but which constrains him to confront the mystery? Can he not take refuge in his own limitations? What reflective man is ignorant of the answer?

Just when we are safest, there's a sunset-touch,
A fancy from a flower-bell, some one's death,
A chorus-ending from Euripides,—
And that 's enough for fifty hopes and fears,
As old and new at once as Nature's self,
To rap and knock and enter in our soul,
Take hands and dance there, a fantastic ring,
Round the ancient idol, on his base again,—
The grand Perhaps!

This fact, sustained by the experience of mankind always and in all ages when it is at its best, sustained by its despair no less than by its hopes, by its agnosticism and skepticism no less than by its faith, leads us to look again at the adventure of philosophy and its assumed failure. What does it mean?

In the first place, it throws a fresh light upon the nature of man. It shows that he cannot escape the sense of his infinite environment. To shut it out of his mind were to rend his own spirit in twain, for it enters within. The infinite is part of the furniture of his soul. He is like a dweller on a little island in the midst of the open ocean, everywhere within the sound of the thunder of the breakers. If he endeavors to satisfy himself with a narrow scheme of life, he finds that he is at war both with himself and with the nature of things. He may seek satisfaction, as Carlyle and many others have advised, by lowering his demands and limiting his outlook. His first crude expositions of himself reveal within nothing but animal wants on a large scale, and he may neither see nor desire to find in the world around anything except that which promises to stay their hunger. But reflection enters if the process of his own rational life is not arrested within him, and reflection breaks down his com-

placency and dispels the fake show of first appearances. His spirit is launched forth on its endless task.

And this *is* philosophy. It is not the quaint guest of star-struck souls which have forgotten their finitude and are doomed to range along the horizon of existence, peering into the darkness beyond and asking questions of its emptiness. Philosophy is the process whereby man, driven by the necessities of his rational nature, corrects the abstractions of his first sense-steeped experience, and endeavors, little by little, to bring to light and power the real—that is, the spiritual—meaning of his structure and of the world in which he lives. I cannot believe in a destiny so cruel as to condemn man to seek and to return home empty. I even venture to say that the quest is *never* vain.

It is true that philosophy does not reach its goal, if that goal is a full and flawless and final scheme. But is it? Which of the enterprises of the human spirit either has, or ought to have, such a consummation? Not the sciences, not any one of the arts, not any form of man's practical activities. There is, with regard to every aim which he has sought to attain, the same incompleteness, imperfection, and lack of finality, and the same ground for skepticism to seize upon and condemn it.

But, in the next place, the skepticism which distrusts philosophy is itself philosophy, and a philosophy which has not been careful to examine its own assumptions. Let me indicate a few of these as we pass on our way.

In the first place, it is evident that skepticism cannot condemn except by reference to a standard or criterion, and that standard must itself be capable of justification, whether through carrying it within itself or as a means to that which does so. It must itself, in fact, assume an Absolute, and a knowledge of it. That which pretends to be true, even

though it be negative, bears within it a reference to a final end, and in its own place and context to embody it. Hence skepticism cannot condemn a conception which it must assume and use in its condemnation.

In the second place, the criterion set up by skepticism is not valid. Skepticism places a static goal for a nature which is through and through dynamic. It demands that mind should come to rest in a knowledge that is final. But self-consciousness *is* a process. To arrest its activity is to extinguish it. It is active no less in possessing than it is in achieving knowledge. For knowledge or goodness *to be*, is to be in process of being maintained by the active powers of the intelligence and will: in other words, the moment that men cease to think and to will, these cease to exist. They are in process of being continually produced. The whole world of mind, like the physical cosmos, is the scene of the play of energies which never rest. Its existence is its *becoming;* it continues through continuous regeneration, and is ever new as well as always old. Both beginnings and endings are fictions. Man's mind lives and moves within a self-inclosed system for which to be is to change, and probably also to evolve, radiating forever into new splendors. And for man to live as spirit is to partake in the process. It is in some other world than that of man's experience that the skeptic should seek a reality that is fixed or a perfection that is static.

In the third place, skepticism has not only assumed for mind an end which contradicts its nature, and is on that account alone irrational as well as impossible: it has also misconstrued the process of knowing. It is represented as self-defeating. Instead of revealing the nature of things as they are, it exhibits them only in their relation to man's means of knowing them, or as they are reflected in the medium of his

consciousness. This is held to distort them; so that in strictness man does not know real things, but phenomenal objects. Mind cannot get into actual touch with reality. It is shut up within a world of appearances; consciousness can deal with its own contents and see only the pictures on its own walls. And, further, every attempt which philosophy has ever made to establish a relation between ideas and facts, or phenomena and real objects, has failed. And its failure is necessary and inevitable, for it is manifestly impossible for reason to establish any relation between what is and what cannot be in consciousness. This suspicion of thought, "this disease of subjectivity," has penetrated deeply into the modern mind, and skepticism has assumed many forms. It is at times the positivism which affirms necessary ignorance of final causes; it is at others an agnosticism which endeavors to stop short of both affirmation and negation; it is at other times an intuitionism which on occasions and for rare moments comes into touch with reality in a way that is inexplicable and miraculous; it is at other times a dogmatism of either the intelligence or of the will that is a resolve to affirm when we cannot know, a pragmatism or a pluralism. In all cases it relegates those things which man most desires to know into a region which lies beyond the reach of his intelligence, or it attributes to subconsciousness, or to mere feeling, or to mysticism and intuition, what it denies to the use of man's rational faculties.

To deal with these skeptical assumptions with any fullness lies beyond my immediate purpose. But we may observe in passing, what is obvious, namely, that the skeptic cannot condemn all human knowledge without condemning his own. His pronouncement on the nature of mind, the relativity of its processes, the phenomenal character of its objects, the

unknowable nature of reality, must share the fate of all other knowledge.

He must choose between denying the validity of all knowledge and affirming his own, and in both cases alike his conclusion is self-contradictory.

But, in the next place, his attitude is exposed to other ways of refutation than that of a mere *argumentum ad hominem* or a *tu quoque*. The skeptic converts the condition which is necessary to knowledge against the possibility of knowledge, as if that which constitutes it could also destroy it. No doubt knowledge is relative; that is to say, it depends upon the nature of mind as well as upon the nature of things. But is its relativity a defect? What would the skeptic have? Is it a mind which has no affinity with the world of objects, or a world which is divorced from, and independent of, the intelligence? The relation of things to mind and of mind to things may be an indication of the fundamental character of both. Indeed, there is no attribute of the real so indisputable as that by which it interacts with mind, and through and by and only during that interaction exhibits and even realizes its fullness of being. Knowledge, or rather knowing —for there is no such ambiguous reality as "a world of knowledge" supposed to intervene between consciousness and the facts with which it deals—*is* the interaction of mind and things, and a living intercourse. And that intercourse is direct and immediate even when we form erroneous opinions. Error is the pathological activity of undeveloped minds. We borrow the whole contents of our intelligence from the world in which we live, even our illusions, and we can *create* neither truth nor falsehood out of the emptiness of an isolated and self-closed mind. On the other hand, the world owes to reason alone the evidence of its existence and the expression of its order and meaning. But we recognize

neither that which we borrow nor that which we lend, and we speak of parts of our knowledge as *a priori* and of parts as *a posteriori*, as if some truths were fabricated by ourselves without the aid of the world, and others were emitted by the world without the use of mind. Knowing is a joint enterprise in which both are involved.

There is, perhaps, no phenomenon of modern thought which demands a closer diagnosis than this "disease of subjectivity," which is not only a cause of the distrust of philosophy, but which would paralyze the enterprise of reason in all other directions, if in our practice, which is wider than our theories, we did not set it at naught. It seems to me to rest, in the last resort, like all the forms of modern skepticism, upon unjustifiable dualisms. For we have been separating when we ought only to have distinguished, and converting differences into contradictions. And, on the other hand, we have been assuming that to reconcile differences is to remove them, leaving nothing but flat and stale sameness. We have not distinguished between sameness and identity, nor realized that identity can—and, I believe, must—express itself in change and maintain itself thereby.

The assumptions arise from the fact that we naturally carry over into our philosophical research the conceptions which we have found useful in our physical inquiries, and endeavor to interpret the phenomena of mind in the same way as objects in the outer world. As in space every part excludes every other, and its continuity allows no diversity: thus only, it is presupposed, can the reality of all objects, including minds, be maintained. They must, we assume, be kept in isolation. Their relations to one another must be treated as contingent addenda: things into which they may enter and out of which they may live again, without any change in their real being. To be real, they exclude one an-

other. Interpenetration, the being of one object through and by reason of the being of other objects, is held not to constitute but to destroy. The finite and the infinite must stand apart. The will of man, if it is to be free—that is, if it is to be a will—must shut out the world. The subject must have only a negative attitude to objects; nature and spirit, mind and matter, must be absolute opposites.

When I endeavor to catch a glimpse of the trend of the thought of the present times, and to define, however generally, the problems in which it finds itself entangled and which it must try to solve, I find that it is occupied with some one or other of these dualisms. The tissue of reality has been torn asunder; and if there be any movement which above all others is indicative of the special mission of the times which are coming, and are already at the door, it is that of healing the rent and of finally refuting all notions of the primacy either of the whole over its elements, or of the elements over the whole. We must find room for the freedom of both mind and the world in knowledge; for both spiritual freedom and natural necessity in our practice; for both God and man in religion; for both individualism and socialism in our politics; for both the one and the many, the universal and the particular, everywhere; and we must view them as interpenetrable; for there is but one reality, and without its coöperation with its elements nothing exists or happens.

Lecture II

We concluded the last lecture by showing that both in our thoughts and in our actions we first distinguish and then tend to sunder the contents of reality: our thoughts are always to some degree abstract and our practical purposes one-sided. Reality, even at its simplest, has more

aspects than we can either recognize or use: it takes all the sciences, each of them taking up its own set of relations, to explain the qualities of a lump of iron ore; and most, if not all, of our industries to extract its uses. All thoughts and all ends are abstract.

But, among the conditions under which man lives, we must reckon as one of the most beneficent that he cannot be satisfied with abstractions. Both his own nature and the nature of things conspire together to secure him against narrowing the interests of his life. The reflected elements of reality press for recognition; and the elements which are recognized refuse to yield either their truth or their use, except in their context. They even refute themselves: one-sided truths become misleading errors, and one-sided purposes refuse to work. They call forth their opposites, and demand to be complemented and corrected by them and harmonized with them. The world resists being shredded into parts, and persistently maintains its concrete totality.

On the other hand, man's own nature also constrains him to move and to coöperate with the trend toward unity. Abstract experience is a mind divided against itself: it cannot stand. Man must either widen his outlook and extend the range of his purposes in response to the call of circumstance, or else do violence to his own rational nature by becoming the bondsman of habit and an automaton. And in either case he makes for some kind of completeness—either the completeness which shuts out or that which lays hands upon and utilizes the environment; and the process of experience always changes him. The final effect of the deeds of his intelligence and will does not lie in the truth attained, or in the purpose realized, but in the recoil of these deeds upon himself. He rises from his acts either with hardened habits and strengthened prejudices, or else with a mind en-

riched with new ideas and a more effective will. Nor by any means can he return to his past. Strictly speaking, spirit has no past; for it always incorporates it with the present. Man gathers his experience into himself; carries it along with him, as an element in his mental structure, assimilated by his living personality. He can sometimes unravel his past out of his present by conscious memory directly demonstrating its presence within him; and even if he cannot give this direct proof of the existence of the past in the present, he gives indirect evidence of it either in the automatization of his life and the fixity and reiteration of his mental operations, or else in the added skill and compass of his thoughts and purposes. This arrestment of the past and its conversion into a living element in the moving life is the mark and marvel of the rational nature of man, distinguishing him above all other things from other beings, as the condition of his progress.

Moreover, it is in this way that he maintains his personal identity. For that consists not in any immutable sameness such as we attribute, rightly or wrongly, to material existence. The self-extenuating space, the succession of the contents of time, each supplanting its predecessor, must be overcome and its flow arrested if personal identity is maintained. And this is not possible except by the activity of a self-consciousness which retains the past by waking it into the present. Even the sameness or permanence of the outer order implies, as Kant has shown, the reintegrating activity of self-consciousness. Reason in man thus becomes ever more concrete, systematizes ever more fully both its own life-content and its outer world. Its war with abstractions is perpetual: to lay down its arms is to yield its life.

It is not a defect of human reason that it must reach the concrete by way of abstractions: it is its nature. Error does

not consist in merely entertaining abstractions, but in treating the abstractions as representative of the concrete whole of reality. It arises when man endeavors to fix the abstractions, or to employ them as final characterizations of reality. There is a true sense in which human knowledge may be said to begin with the particular and the simple, and to make its way toward the universal and concrete—to start from "the Many" and to seek "the One." But there is also a true sense in which knowledge may be said to begin with the indefinite "an undistinguished continuum," and to proceed to articulate and define its contents—to start from "the One" and to seek "the Many." From the first point of view, our experience is at first a sensuous manifold which has to be connected first into perceptions, then into conceptions, and finally into the organic and hyperorganic ideas of reason. And, *pari passu,* the object of experience, nature, at first appears to be the scene of disconnected happenings and to be a loose aggregate of unrelated facts, and eventually to appear as a universal cosmos. From the second point of view, our experience is at first a confused mass of sensations pressing into us through the pores of sense, and perceptions arise by distinguishing and articulating. And the object of experience, the world, changes its character in a corresponding way. Now error arises when either of these views is adopted against the other, or as the whole truth, and made the basis of a philosophical account of the real. And that it is an error is shown by the necessity of correcting the original hypothesis by means of its opposite. For whichever presupposition we assume at the beginning is nothing but a starting-point from which its complementary opposite must be reached. If the pluralist begins with the Many, particulars he must confessedly synthesize and unite; if the absolutist begins with the One, the indefinite whole he must analyze and

articulate. Philosophers may differ as to the nature of reality, and their doctrines may range between an absolutism or pantheism that engulfs the many and deletes all differences, and a pluralism or monadism. It is true that neither on the side of its difference nor of its unity is human knowledge complete—that is to say, the distinctions which are made are not clear, differences escape our observation; and, on the other hand, the unity in which they are comprised may have both little compass and little significance. But pure difference and pure sameness baffle the intelligence by their meaninglessness; indeed, neither can be affirmed or denied except in relation to its opposite. Every judgment, every opinion, false or true, wide or narrow its influence, implies differences within a unity, and is always a system. The assumption of pure particularity which the pluralist makes, and of pure unity or sameness which the absolutist makes, is not valid of the object of knowledge at any stage, from the crudest ordinary consciousness to the completest constructive height of the speculative philosopher. The problem of passing either from the Many to the One, or from the One to the Many, is insoluble; but it is also a problem that the human mind is not obliged to ask. It is a problem asked neither by the nature of things nor by the nature of reason. It is as unnecessary and as insoluble as the problem of proving that $2 \times 2 = 91$. And the way to deal with such a problem is not to ask it. The several philosophies which ask the question are the ordines of abstraction, and their error is revealed whenever the abstractions are faithfully pressed home. They will then be seen not only to call forth, but to pass into, their opposites, and thus to refute their own starting-point.

A general survey of the reflective thought of the present day will prove, I believe, that it is engaged upon this task; and its main province lies in the explicitness of the assump-

tions and the rigor with which they are being followed to their conclusions. At no previous time were the advocates of the Many and of the One so frankly opposed or so evenly balanced, nor their contradiction more direct and full. Except in one or two instances, pluralism exists in order to complete absolutism, and means to have no mission except to maintain the existence of contingency and multiplicity, and it must itself perish in the hour of its victory. But the pluralism which aims at being constructive is an unusually interesting phenomenon, and much more characteristic of the times than the absolutism which it would refute and supplant.

As a matter of fact, the absolutism which is supposed to begin with a bare "universal" or "One," and to proceed to evolve the varied contents of experience from that "One," employing an *a priori* method of mere analysis, need not detain us. Such a method may have been employed by the Eleatics, and can be attributed, not without justice, to Spinoza. It is also supposed by critics to be employed by Hegel and his followers. But it does not concern us at present to determine by whom the theory is or has been maintained, nor under what great names it may shelter itself; for we are not engaged with the history of philosophy. We need not seek to ascertain whether the Absolute of Hegel stood for an empty One, or for the whole of reality as it is in all its concreteness in itself and for itself. Only the first, as the abstract Absolute, engages the attention of the pluralist and concerns us.

But it concerns us only to be dismissed. I admit at once, and without any reservation, that philosophy cannot begin from such an Absolute; that if it could begin, it could find no way from it to the rich complexity of real being; and that the method of mere analysis and *a priori* deduction can elicit nothing out of its emptiness. No doubt the psychological

history of man's mind may give evidence of a process by which the indefinite mass of its original sensuous consciousness is distinguished into elements and sights and sounds, and even the Ego and the non-Ego are practically defined and their differences made explicit. But absolutists are held to be guilty of neglect, or even contempt, of psychological evidence rather than of converting psychology into a metaphysical absolutism, though I should find great difficulty in admitting its existence elsewhere than in the minds of its critics.

But it is not so with the opposite theory, which professes to start with "the Many" and to seek "the One"; which maintains that particulars are given and universals are found; that experience proceeds from discrete sensations to perceptions, and from perceptions to more general conceptions, and from those to the still wider "ideas of reason"; and that the object of experience, the whole region of ordered facts, presents itself at first as the scene of separate, individual occurrences, and an aggregate of things real in their independence of one another, each of them isolated, impervious, exclusive, an object of simple apprehension. The pluralists maintain, in so far as they are logically faithful to their fundamental hypothesis, that such is the true or final character of reality. If we affirm its unity as a whole, or the harmony of its elements in virtue of any universal principle or law of being, we go beyond our evidence: we even flout the facts. All the objects of man's thought are finite; even God is one among, or, what comes to the same thing, one above and over above, other beings. Real existence implies singularity. A thing, in order to be, must be itself, must carry within it a private core, which is its own true being, and which remains its very self, whatever relations it may enter into or come out of.

All realities are particulars, we are told. Nothing exists beside particulars. There is "no *unity*" or common element, no real or existential universals, which exist or subsist in addition to the particulars. There are no things-in-general, and no events-in-general. Nothing exists which corresponds to such a general conception as "animal" or "tree", or "man"; but only this or that animal or tree or man. Nor is there any universal substrate which constitutes them into a class. A class is due to our classification: it is an idea, not a thing. We may, and do, find similarity between different objects: but each of them exists in and by itself, and the similarity is an idea which we form by comparing them with one another. Anything that destroys their intrinsic singularity or uniqueness destroys them: for them to be is to be each its own unique self.

How, then, do we account for law and order? It is simply and purely the outcome of intelligence. Everything that exists is its own law, an active essence, or character, behaving in its own particular way. There are, therefore, no repetitions in the realm of the real, any more than there are similarities, and no absolute fixity. Repetition, enumeration, measurement, mathematics are not possible except by abstraction, and are not true of any real existences. "All our assertions of identity among reals are at bottom negative, amount simply to saying that we discern no difference."

But what comes of this view of the universal laws, which science seeks to establish, and the uniformity of nature which they postulate? Does not this doctrine "let contingency into the very heart of things"? Must not a perfectly discrete world be in every part of it unintelligible? The consistent pluralist answers these questions in the affirmative. So far as science deals in universals, it does not touch the reality of things. Thought must start from the particular, but it can-

not return to it. Thought gives us only the universal, and universals are only hypostasized epistemological entities. Facts and universals, in short, belong to different orders: the former to the world of objective reality, the latter to the objective world of knowledge. Moreover, they do not even correspond. The universals are not true—that is, they indicate no existing realities, as perceptions may do. The so-called laws, and the universal and necessary causes of which natural science speaks, correspond to nothing that exists in reality. There are no laws or necessities or uniformities of nature. These are mere results of our own thinking, conceptions fabricated by our minds through observing, selecting, summarizing and generalizing the multitudinous, particular occurrences which really take place. "In the real world we can nowhere find that exact similarity which the mathematician can readily conceive, and the contention is that it nowhere exists." "There are never two beings which are perfectly alike, and in which it is not possible to find an internal difference"; and, *a fortiori,* no two events or occurrences or activities can be identical. There is, to our loose and general observation, an apparent repetition of events, of acts in the world, and we speak of "same causes" and "same effects"; but sameness and uniformity, together with the continuity and necessity which are assumed to spring from them, are mere thoughts. There are no natural laws, nor any real being corresponding to any concepts the physicist can find it convenient to frame regarding the ultimate constituents of matter. Continuity must destroy particularity. Each real thing has its own unique constitution. Pluralism thus does not hesitate "to let contingency into the very heart of things." "I not only admit it," says Dr. Ward, "but contend that any other world would be meaningless."

But there is another application of this pluralism to which

I must briefly refer. It is its application to the *subjects* of knowledge. The particularity, uniqueness, and exclusiveness which is the essential character or true being and essence of natural things, is attributed to minds, and to their experiences. Every mind exists, and for itself. There is no continuity between or in them, and each is absolutely impervious. Every mind maintains the absolute isolation of its own being. And the same holds of their experiences—or the same would hold if any general affirmation could be true. The presentations of one man cannot become the presentations of another. Every mind is the exclusive owner or retainer of its own truths and its own errors. To every self its own world, to every Ego its own non-Ego. Above all else, we must not play fast and loose with the uniqueness and isolation—with the being in itself and for itself—of personality, or of its experience.

How, then, can they agree? How can they disagree? How is any communication between them possible? Not by changing places, not in such a way that "the presentations of one could become accessible to the others." "This is just the most impossible thing in the world. Individuality consists precisely in this impossibility." There is no element common to the several experiences. Each monad mirrors its world "from a unique standpoint of its own." Universal truth, in the sense of a truth that is possessed or attainable by all minds, has to go the way of all other universals; and if general conceptions are still possible, they are possible only in the sense that every mind has its own private stock of them. There are thus as many experiences as there are persons, and as many sciences as there are scientific men—probably more. And they are all interpretations, equally true or equally false—if, indeed, either falsity or truth can appertain to different worlds where every mind has its own object.

Pluralism implies solipsism. "So far as reality consists in particulars, so far it pertains to each experience for itself alone; and so far the solipsist in theory, and the egoist, a solipsist in conduct, are logically unassailable, even though the proper place to put them be, as Schopenhauer said, the madhouse."

But we have just seen that on the pluralistic theory reality consists exclusively of particulars. What, then, can be the meaning of introducing the qualifying phrase "so far"? It is necessary in order to escape from solipsism, and, in other words, to enable the several persons to communicate with one another—communication consisting "in establishing relations between these primary realia." There must be a medium for mutual understanding, and by means of it they must arrive at common knowledge.

But what can "common knowledge" mean for the pluralist? Evidently not that the knowledge which L has is also possessed by M and N. They "cannot change places so that the presentations of one become accessible in their actual entirety to the others." "This is just the most impossible thing in the world. Individuality consists precisely in this impossibility." The knowledge of L, M and N may conceivably agree, but no part or element of the knowledge of L can be the knowledge of M or N. Each of them "mirrors the universe from a unique standpoint of his own." Every Ego has its own non-Ego. "Thus, when in place of the Ego L we have M or N, so too in place of the non-Ego non-L we have non-M or non-N." The mutual independence and isolation of the subjects of knowledge thus carries with it the isolation and mutual exclusion of the objects of their knowledge. All experience, to begin with, is, we are told, "individual." It is the private knowledge of each person, and it is a knowledge of different objects. When ten men look at

the sun or moon, "each of these persons sees a different object." How, then, and in what sense do the ten come to know that the actual object of each is the same individual object for all? How can they hold any communication with one another so as to agree, or even disagree? "Except on the basis of individual experience, communication is impossible," for it is evident that, first of all, each must have something which he wishes to communicate. The difficulty would seem to be insuperable.

It is overcome, however, by one author in a very simple way. He assumes just the least possible "common knowledge"! "The most that L can indicate or communicate to M of any part of his own experience is so much of it as is common to the experience of both." We may be sure that the earliest intercourse is very slight: just simple indications, a mere pointing to a particular thing as this or that. But once it is begun, the process goes on successfully. "We point to other particulars resembling it, other shining, moving, round objects, and so, by suggesting its likeness to these, take the chance that parallel relations or comparisons will be verified by our fellow-men."

Criticism of this view seems to me to be superfluous. It is directly self-contradictory; and the contradiction is not in the least removed by admitting as little common knowledge to begin with as possible. For "common knowledge" or "common" anything is just what pluralism denies.

Nor does practice come to the help of theory, as we are asked to believe. I do not doubt in the least that "the case of ten hungry men and a loaf would be an impressive object-lesson"; and it ought to be specially impressive to the pluralist. For he would find it difficult to live up to his theory were he one of the ten. To do so, having his own unique experience of his own unique loaf, he should not object to any of the

others eating their own unique loaves—supposing, indeed, he could be aware of their loaves. A pluralism that is consistent is certainly not supported by practical experience, and there is absolutely no transition possible from individual experience, such as it is represented by the pluralist, to that experience which is universal in the sense that different men understand one another and mean the same things by the same things.

It would be interesting to observe the manner in which the pluralist repeats, in his final philosophical account of reality as a whole, the same contradictory process as he employs in order to enable his theory to start on its way. For we find that the deity is introduced as a background of unity, or as some kind of substrate, or is even spoken of as "immanent." It is admitted, however, that such a conception of the unity of the whole cannot be "empirically verified." "The pluralist halts at the Many and their interaction; he declines to go further because he finds no warrant for so doing." But if it is objected that the hypothesis of unity is of no use unless it can be verified, we are reminded that philosophy is not science. Science must verify empirically. The facts with which science deals "fall within experience, and this is sure, therefore, sooner or later to furnish a crucial test of the validity" (of its hypotheses). But philosophy cannot justify its ideas in this way. It employs another method. It justifies its "ideas" by appealing to "experience as a concrete whole"; "and they are justified in proportion as they enable us to conceive this whole as a complete and systematic unity." But, we ask, is not the conception of the whole as "a complete and systematic unity" precisely what the pluralist cannot have? For, as we are told in the next sentence, "the pluralist halts at the Many and their interaction; he declines to go further because he finds no direct warrant for doing so."

He gets his indirect warrant by an appeal to theism—that is, by an appeal to that which cannot be included in his theory because it contradicts it. The pluralist, being also a theist, admits a unity for which he has no warrant in experience, and with which the facts which *are* held to be given in experience, being a "Many," are directly inconsistent. Pluralism begins and ends with a contradiction.

The failure of pluralism in its application to the objects of knowledge is not less evident than it is in its application to the subjects of knowledge. The relation of the former to one another is as unintelligible and impossible as intercommunication between the latter. In fact, the problem in both cases is the same; for all objects of knowledge turn out to be in the last resort all subjects of knowledge, and all "things" are held to be persons. "The only things of which we have positive knowledge are subjects with intrinsic qualities, things that are something in themselves and something for themselves."

The pluralist admits relations between objects, as he admits the intercommunication of subjects and an experience which is universal. But they are not relations between *things,* in the sense of existing over and above that which they relate. There are not things here and relations there; in other words, there are no existential universals.

What, then, are relations? They are the activities of particulars, "the intercourse, the coöperation or conflict, actual or possible, of the individuals themselves." "The passion and action of things must take the place of relation. . . . There are no objective relations other than this living action and passion." But we know nothing that is active or passive except minds, and nothing else can be for itself. Hence "the only *causes* of which we have positive knowledge are minds: these have a nature of their own, and hence can interact,

determine and be determined." Pluralism ends in panpsychism. "The attractions and repulsions of which the physicist speaks only metaphorically, are to be taken literally —that is, as implying impulses initiated and determined by feeling." "For modern pluralism the universe is the totality of monads really interacting." The "Many of pluralism constitutes the class of entelechies or persons in the widest sense—beings, that is to say, who are something for themselves, conative and cognitive individuals bent on self-conservation and seeking the good." "They are severally related by their mutual interaction. . . . We have not two distinct and separable facts—first, the Many, existing in isolation, and then their interaction." "The universe is the totality of monads really interacting, and this is one fact." "The plurality implies the unity, and this unity implies the plurality—a fact which is an inexhaustible wonder."

Now it is evident that the crucial question for this doctrine is the possibility of the interaction of the monads, or the cognitive and conative persons into which all reality, including so-called material reality, has been resolved. But we have found already that this is impossible, and I shall add only one consideration to those I have already advanced.

Let it be assumed that the monad or personality A knows and wills, and also that for it to *be* is to know and will. Let it be admitted, further, that monads B, C and D do and are the same. It is plain that the action and passion of A are exclusively its own; so also are the actions of B, C and D. Is it less plain that in that case the *relation* or *interaction* of these several experiences, supposing it does result, is no part of the action or passion of any one of them? The assumption that the actions and passions do interact, and that they are experienced as interacting, may be quite true: but for the pluralist it must not only be made gratuitously and dog-

matically, but in flat contradiction of the fundamental hypothesis of the particularity and exclusive individuality of every item of the "Many."

Moreover, I must ask one more question of the pluralist. Can any particle, monad, person or subject either be active or passive purely from within itself? The pluralist finds his clue to the nature of all reality in his own mind. Has he known his own mind, either mind or will, entirely apart from the universe in which it exists? Is action or passion *in vacuo* possible? And is not a mind out of all relation to the world, a self which has no not-self, a vacuum and pure fiction? To will, think, or even feel nothing is neither to think nor will nor feel; and a mind without any "content" is a nonentity.

On the other hand, if it has a content, that content, for all the purposes of "conation and cognition," is an object and a non-Ego. But an Ego which has its non-Ego or world as its content or object of experience is not the "particular," exclusive Ego of the pluralist. It at least implicitly contains its world! The Ego, instead of being exclusive and particular, turns out to be at least potentially all-comprehensive. The individual mind *is* the subjective expression and the spiritual focus of the universe. It is a Many in One; and to explain how this can be is the paramount problem of philosophy.

It is an old problem, this of the relation of the One and the Many; and I agree entirely with Dr. Ward when he says that "the solution is not to be obtained by passing over the Many at the outset, trusting to deduce them afterward from an absolute One that is reached *a priori*"; and that "this method has proved itself illusory; the seeming attainment of the One has meant the disappearance of the Many." If, as he avers, Fichte, Schelling, Hegel, Schopenhauer, and others less distinguished verily held such an "absolutism or singularism,"—a question which I do not raise at present,—their

recent thought does well in recoiling from their doctrines. I can only say that I have not understood them in this and that way. On the other hand, I find that Dr. Ward admits that pluralism has also "failed to reach a satisfactory solution of the problem of the One and the Many"; he allows "that no philosophy has ever managed to reconcile these two notions of an infinite power and an infinite variety of limited, individualized expressions of that power." But I would apply to pluralism, *mutatis mutandis*, precisely what he says of absolutism or singularism. The solution is not to be obtained by passing over the [One] [Many] at the outset, trusting to deduce [it] afterward from the Absolute [Many]. For the Many is not "given." The pure Many is as much an *a priori* construct as the "Absolute One," and as little given in experience. And as it is admitted that "Pluralism fails or has so far failed to account for the unity that it in fact involves," then the right and the duty of recoiling from the doctrine is as absolute and imperative as the right and duty of recoiling from its opposite.

Indeed, the promise as well as the problem of the philosophic thought of the twentieth century arises from the exposure of the impossibility of both of these abstract theories, and its rejection all along the line, from the most elementary perception to the most comprehensive reflective knowledge of the premises and the methods of both.

Lecture III

NO theory can be satisfactory if it is inconsistent with itself; and none can be satisfactory if it attains self-consistency by merely ignoring or abolishing differences. Pluralism cannot afford to be self-contradictory, and singularism or absolutism cannot afford to affirm empty sameness. These rival schools, starting from opposite poles and

employing opposite methods, would arrive at the same goal. They would admit in their scheme both unity and diversity, and they would reconcile these notions. And reconciliation would, for both alike, mean more than the admission of unity and diversity side by side. The One must be explicable only through the Many, and the Many only through the One. Such is the acknowledged condition and criterion of philosophic truth: it cannot contain ultimate incongruities nor be incomplete; it must be a system which is all-comprehensive, and in which all the elements have their own place and function.

It ought, it seems to me, to be obvious that the condition and criterion of reality must in these respects be the same for the *real*. To maintain a different criterion of truth and reality is not possible with establishing a fundamental discrepancy between them at all points. Reality can as well contain ultimate contingencies as truth can contain ultimate contradictions. Pluralism must as a philosophical theory be a doctrine of the universe as a whole, and if its doctrine must be self-consistent its universe must be one. And absolutism, if its "One" is to have meaning, must affirm the real diversity of the real. In a word, on any theory, the destiny of reality must be the same as that of truth. Epistemology and ontology, even for those who recoil from saying that "reality is experience," must be two names for one doctrine. For the real gains no expression except in knowledge, and knowledge must have the real for its content.

No one will affirm that the concrete truth of the concrete real either has been or can be attained by human knowledge. In that sense no philosophy has ever pretended to be "absolute." But we found in the last lecture that such a truth cannot be approached, and that not even the first step can be taken toward it by a philosophy which omits either the

One or the Many from its original premises. There is no way either from differences to unity or from unity to difference. Indeed, it might be shown that both pure difference and pure unity are confused and contradictory notions. To endeavor to start from either the one or the other is to start from the abstract and the meaningless.

What alternative remains for philosophy? Evidently to start from unity as expressing itself in diversity, or as already concrete. Knowledge must exhibit at every stage—even the first—the essential characteristics of a system. Every object, whether it be that of immediate perception or that of philosophic reflection, whether it be a so-called simple fact or the universe in its totality, must have the character of individuality. This means that it must consist of parts or elements between which there are real differences; but, at the same time, the differences must so complement and sustain one another as to constitute one reality. And that reality is not the mere sum of the parts or elements, nor is it anything superimposed upon them by way of a containing supplement or envelope. For the one can neither be indifferent to the elements nor independent of them; nor are they, on their part, indifferent to or independent of one another or of the whole. The One and the Many must derive their intrinsic character and their very being and function from each other. They must be distinguishable, for they are different; but they must not be separable, for they constitute a unity. On the other hand, they must be *One*, for they are forms of one reality; but they must not be fused into sameness, for they are different. But this means that individuality belongs both to the whole and also to every real element of the whole or instance of the Many. To deny the individuality of the whole is to disintegrate it into inexplicable and unreal differences, every one of which "is a surd

for thought" and to deny the individuality of the parts or elements is to reduce unity to emptiness and to make it meaningless. Hence, further, the One and the Many must be both dependent upon and independent of each other. They must exist in themselves, and nevertheless exist only in virtue of their relation to each other in a whole which is at once constituted by them and constitutive of them.

But, it may well be asked, does this not also imply that philosophy starts from and deals with a self-contradiction? It depends, I shall try to show, on the meaning of "individuality," of dependence and independence, of real being and of relation. In all cases it is *the* problem of philosophy to explain this apparent enigma. It is not to show *that* this view of the individuality and reality of the whole and of all its elements is true. We have seen that philosophy postulates this view of truth and reality in attempting to be a coherent or systematic doctrine. Nor is the postulate a mere *a priori* assumption, unsustained by experience. On the contrary, there is no department of experience which does not contain, or rather consist of, instances of the unity of the diverse, and of the diversity or complexity of the One. The problem confronts ordinary thought on every side, only it ignores it, and it is presented in every one of the arts and sciences. Let me exemplify this fact by citing one or two examples. When four voices sing together the notes C E G C′, or G C D, or D F A, harmony ensues. Now harmony is not mere unison, nor is it mere multiplicity. It is a single effect in which all the voices are fused into unity, but the fusion does not annul the differences nor destroy the individuality of the voice. The individual harmony consists of individual voices each of which is enriched by its relations and intensified in its beauty.

It is evident that the same holds of a piece of music as a whole. It consists of sequent movements, the first of which passes away to make room for its successor, and yet the character of the movements which come last depends upon—that is, somehow carries within—what went before, and continuity—nay, unity—remains *by means of* the succession.

Every work of art exhibits the same character of being a One in value of the Many, and presents the same problem. A turret depends for its artistic value upon the place it occupies in the edifice; and so does the artistic value of the edifice. Each gives and borrows its significance and worth from the other, and yet each has its own meaning. So it is also with a picture or a poem. Both the parts and the whole have their individual being and value, and yet these depend on their relation to one another in the whole.

When we turn from the arts to the sciences and to philosophy—to systematized knowledge—the same truth holds. The meaning of a statement depends upon its context and all its cognitive value. A statement may be rendered meaningless by changing its context; and truth itself becomes error when it is placed out of "the appropriate universe of discourse."

Nevertheless the unity of the systematic truth is not obtained by mere fusion. Every element in it retains its own value, and makes its own contribution to the whole. When the mathematician, for instance, proves a theorem in geometry he is engaged in demonstrating one, and only one, truth: *e.g.*, that the angles of a triangle are together equal to two right angles. But the single proof of a single truth somehow consists of many truths, and these are at once independent and interdependent. They are independent in that they cannot be done without, and nothing can replace them or perform their function in the proof; they are interdependent in

so far as none of them has either significance or value except by reference to one another and to the single truth they subserve.

In short, the testimony of rational experience to the reality and the interdependence, to the individuality and to the essential and even constitutive interrelation of the Many and the One, is universal. The mere Many of the pluralist and the mere One of the absolutist are alike nothing more nor less than fictions. Experience gives no example of them. They are the results of the abstract treatment of experience.

It follows, therefore, that the interpretation of experience, which philosophy is, must accept this apparent enigma. Its problem is not to show *whether,* but how, this can be possible—to maintain the reality both of the One and the Many, and to reconcile in its theory what is already reconciled in reality.

But to maintain this view of philosophy, and to carry it out into its results, is to challenge a formidable array of abstractions. For, as we have already seen, the tissue of reality is torn by human knowledge and its seamless raiment rent asunder. We convert differences into contradictions, and isolate and fix our distinctions; and, in consequence, we find the differences irreconcilable. The reality and independence of the Many is assumed to imply that they are exclusive; and any degree of community of existence is held, as a matter of course, to destroy their individuality. The sway of abstractions is very wide.

Nevertheless I believe, as I have said, that if there be any movement of thought in this twentieth century which specially characterizes its mission and promises significant results, it is that of first exposing and then rejecting these abstract opposites. It is, in one word, to repudiate the categories—what Kant by a new abstraction called the Cate-

gories of the Understanding, which are the categories of external and of both contingent and necessary relation. It is to reject *in toto* the view that the reality or individuality of anything can consist in or depend upon its isolation. It is to discover that to negate is not to contradict, and that to affirm is not to reduce into mere sameness. On the other hand, it is not to say that reality consists of relations; but it is to say that it is not independent of relations, and that if relations are abolished nothing whatsoever remains. It is to hold steadfast to the truth so plainly illustrated in every work of art, which consists at all times of individual parts every one of which has its own character and function, and which nevertheless is dependent for both its character and its function upon the work of art as a whole. For, whether we can explain it or not, a piece of music does consist of individual notes, and not of mere relations; and yet if the relations between the several notes be annulled they are changed, and no music remains. And whether we can explain it or not, every rational judgment, true or false, makes *one* affirmation, and that affirmation contains a diversity of elements.

But if this be the special mission of the philosophy of the twentieth century, it must be admitted that the promise of its fulfilment is, so far, faint. Its exposure of the necessary failure of the one-sided assumptions of both pluralism and abstract absolutism is incomplete. It has not taken to heart that experience furnishes no example of either mere unity or mere diversity, and that these rival theories have pure fictions for their premises. Hence it has not repudiated either the method or the aim of these abstract doctrines. It is continuing the attempt to bring the One and the Many together, instead of proceeding from the presupposition that they always *are* together. Its process is *either* synthetic *or* analytic; synthetic in so far as it seeks to proceed from the mere

Many; analytic in so far as it seeks to proceed from the mere One. It does not begin with the conception of system, of reality as a concrete element, nor proceed to observe its growth or evolution, by which unity becomes more deep and significant and the diversity of the parts more clear.

Let me illustrate this truth in the first place with regard to knowledge. The subject of knowledge—namely, the finite, rational self—is still regarded as a *res completa;* and the object which the subject seeks to know is regarded as another *res completa.* The problem of knowledge, therefore, assumes the form of showing how they can be brought together. And, further, it is assumed, though with a confidence sharply shaken, that the way of bringing them together is to resolve the one into the other, or, in other words, to abolish the difference between them. And if we have despaired of resolving the subject into its object by the way of materialism, we have, on the other hand, not repudiated the opposite method of resolving the world into the subjective experience of one or more subjects. Subjective idealism is still in vogue, for we say that reality *is* experience, and in panpsychism the monadism of Leibnitz is being resuscitated, so that all reality is made to consist of what one may call spiritual points, which have only intensive magnitude and no "body" except their own activities.

It is true that philosophers now speak of *subject-object,* and will even admit that spirit and nature are somehow correlates; but only the most limited use is made of the conception. And when it is affirmed that reality *is* experience, "experience" is allowed to remain utterly ambiguous so as to carry *either* an objective *or* a subjective reference at will. Or when it is explained, as for instance by Mr. Bradley, experience, and therefore reality, is said to consist of feelings, thought and volitions, and subjective idealism reappears.

That little use is made of the conception subject-object beyond the admission that reality is somehow spiritual, is evident from the fact that the psychologist, and also the epistemologist, not only distinguish but separate the functions of mind and things. The world of reality presents the data for mind, and mind then makes the knowledge. But the world cannot give until the mind takes, and the mind cannot take until the world gives; and there is no priority of any kind, either temporal or logical. The statement that reality is experience is meant to convey their intrinsic correlation. But the statement is allowed to remain vague; and experience is, after all, made to belong exclusively to the subject. It is *his* living conation and cognition, and the object world is its product; and the idealism which practically all philosophers now profess becomes a doctrine which reduces reality either into phenomena of consciousness, such as thoughts, feelings and volitions, or into spiritual monads, more or less confused personalities.

But consciousness cannot be active—that is to say, it cannot be consciousness—except in relation to objects, and the *data* of knowledge cannot be the *results* of knowing. Hence the function of the real in the act of knowing must be restored, and consciousness, with all its activities, must be *its* activity *as* consciousness, and as a consciousness which is individual. We must make room for the function of both mind and the world in knowledge, and maintain that, as separate, they can neither do nor be anything. Knowledge proceeds neither from minds nor from objects. It is the self-revelation of the whole which comprises both, and *is* both in their interaction. However true it may be that experience is subjective, personal, private to every individual finite spirit, it is still a consciousness which has contents, which exists only by reference to it, and which cannot make it. To account

for knowledge we must assume a reality which is wider than either subjects or objects, because it comprehends both, and neither is except in relation to its opposite. To begin with, *either* is comparable to the process of a mathematician who looks for a product by beginning with one of the factors, starting from *either* 6 *or* 7 in order to arrive at 42. Knowledge is the result of the interaction of the two aspects of reality which we not only distinguish but separate and then strive to bring together. We endeavor to find a way *out* of consciousness and *into* a relation with facts, whereas we *are* at all, and are conscious, only in virtue of our relation to the reality which comprehends both our minds and the facts.

But if this is true we shall cease to speak of the self and the not-self, of subjects and objects, of mind and matter, of soul and body, of spirit and nature, of God and man as *first* existing apart, and then brought together through the interaction which reveals itself in knowledge, in the fine arts, in morality and in religion; for that interaction is, as we have seen, impossible unless they *are* together. Our distinctions must remain and the differences must be real, and the individuality and even the personal privacy of the human spirit be maintained, but they must be maintained within the unity of the real which comprises both the opposites.

That the thought of the present day is making toward this genuine universal standpoint is not to be doubted. There is evidence of it especially in such doctrines as that of the "natural-supernaturalism of Carlyle," in the spiritual realism of Goethe, of Wordsworth; in the indefinite view of the immanence or indwelling of the divine in nature; in the repudiation of materialism by natural science and its clearing consciousness of the abstract character of its hypotheses and task; in the growing conviction of the intrinsic interaction of man and society; in the growing suspicion of both individu-

alistic and socialistic theories, and in the thinning down of the partition between the secular and the sacred, so that man finds his duty, which is his spiritual opportunity and privilege, in every station, and believes that every service of man may be the service of God. The sense of man's affinity with the universe is deepening in every way, and the universe itself seems to acquire a spiritual significance *because* man is an element in it.

The justification of this new attitude which philosophy must furnish is difficult. But psychology on the one side, and logic on the other, are preparing the way for the new metaphysic. The former finds no evidence that mind, however spontaneous, can create its own content. Even imagination, when it is more free, only selects and rearranges. If it creates its heaven as it pleases, it must borrow its material, as Hume has shown, from the present world, making its streets of gold and gates of pearl, etc. All knowledge is both relative and anthropomorphic, just because both man and his world are necessary factors in the function of knowing. If man is and must be spontaneous in his cognitive and conative activities, it is not because he is separate from the world. In isolation he is helpless. As he cannot lift a hand or move a foot except by means of the resistance which is also the help of the physical cosmos, so he can neither know nor will, and is in fact only a name or nothingness in his isolation. The world is not a hindrance to man's "spontaneous" spiritual activities, but their indispensable condition. In truth, his knowledge is the activity of the real in and by him; but it is his knowledge none the less, for by it he comprises the real.

On the other hand, his affinity to and dependence upon his cosmos is also its dependence upon him. The cosmos of the materialist is as inconceivable as the knowing subject or de-

tached self of the abstract idealist. If mind *is* not except in its relation to the object, neither is the object except in relation to the subject. The dependence is interdependence, and the real is never only one of its aspects. It is neither natural nor spiritual if these are considered apart.

Nor does the dependence of the world of objects on mind mean that mind, as we know it, makes them, and in making them infects them with its own subjectivity. The objects do not turn out on examination to be nothing but experience, if by experience is meant—as it ought to mean—thoughts, feelings and volitions, which somehow become substantiated into these ambiguous realities, hovering between being and non-being, which we call phenomena. There is no such thing as a "world of truth" which stands over against things in themselves, and mediates between them and minds, being, as Lotze called them, "a replica" of the real. The problem of discovering the connection between ideas and their objects, and all the attempted solutions of the problem by making the former images or symbols or representatives of the latter, or the latter reifications of the former, are as unmeaning and futile as the problem of the relation of the world of fairies to the world of every-day life. There are minds and there are things, and because they are elements of one reality they interact. During their interaction there is knowing, and the result of the activity of knowing is to modify the subject which knows so that it can repeat the process, even when the objects which first contributed to it are not present. But there is no such result as a concatenated system of ideas, nor even a single idea that has any permanence or being of its own. The relation of minds and of things is *direct* in the last resort, and the relation between them is constitutive of both.

But this, it will be said, makes reality depend for its existence upon being known, and at the least derive a new stage of existence and a higher manifestation of itself from and through man's mind. In that case must not the act of knowing defeat itself? It is the object of knowing to apprehend facts as they are; but that is surely not possible if the act of knowing changes them. Knowing them changes them, I should answer, and defeats thereby its own purpose, only if we continue to assume the dualistic point of view which, at present, we are endeavoring to repudiate, and continue to treat them as separate existences *brought* together. But the difficulty does not arise if knowing is neither the function of mind nor of objects as apart, but of the reality which comprises them both as elements and aspects. From this latter point of view reality may be shown to enrich itself, to allow fuller being, to set free and to realize new potentialities through the cognitive activities we have been attributing to the self, but which belong to it as comprising the self.

An illustration may indicate the possibility of the truth of the view I am trying to express.

The physicist is supposed to give an account of sound. He tells us that it is wave movement. But the least analysis will show that he professes no such thing. He explains only *one* of the conditions of sound. Apart from the psychological structure of the human organism, and also apart from the presumably non-physical but psychological structure of his consciousness, there is no sound. Delete any one of these three distinguishable elements—the physical, physiological, or psychical—there would be no sound and the universe would be silent. Sound is not analyzable into any one of these factors, nor attributed to any one of them rather than to the others; and when all the elements of a unity are necessary there is a true sense in which it is not possible to give priority to any

one of them. On the other hand, it is true that the physical conditions of sound—the wave movements produced by the pressing down of the keys of the organ and the filling of the pipes with wind—gain new significance and value when the organ is played by a great artist and the physical conditions are subordinated to the musical purposes of a great composer. The coming in upon the scene of the musician's soul reveals a new range of meaning and beauty which before were dormant in the physical structure of the natural world; and reality as a whole, which has produced and contributed to the instruction and which comprises the musician, assumes through him a new way of being. And yet, though without him there can be no music, we cannot attribute the musical effect to him alone, as we do knowledge, an experience, to the activities of the subject. Without his context he also is helpless. The distinction of *meum* and *tuum* does not hold. The musician's spontaneous—or, as we say, creative—power is conditioned by the real world as a whole in which he lives and moves and has his being, and at the same time the real world needs him in order to realize the significance even of its natural elements.

This illustration suggests the possibility of maintaining that finite minds by their cognitive and conative activities have a more significant function in relation to the world of reality than that of "manifesting" or "expressing" its meaning in the way of truth; and that their relation to it is more intimate than can be accounted for by any theory which attributes their activities to themselves alone, and which makes consciousness contain an idle, epistemological replica of reality. If in order that there may be music, or any other of the productions of fine art, reality as a whole comprising the artist must be effectively present, so reality as a whole must be that which thinks and wills. Not that minds in willing

and knowing are mere instruments upon which the world of reality plays, or by which it gains better and fuller expression. The idea of "instrument" is inadequate to the occasion, and we obscure the trutn and lapse back into dualism when we represent minds as *operated upon.* It is the mind which introduces the purpose. In the case of both the musician and the scientific man or philosopher the natural elements of the cosmos are in a sense subordinated to their purpose; and yet the purpose is not alien to the natural cosmos, or superimposed upon it from without. For nature's own potencies are realized in and by them, and in him they acquire themselves a better and fuller way of existence.

But in that case we must start from a new hypothesis as to the nature of reality. We must no longer speak of it as *either* natural *or* spiritual, nor, in order to account for it, endeavor to make the natural disappear in the spiritual. Nature as merely natural is now discovered to be only a fragment of reality, even of reality as finite minds know it. It is and remains "natural," for it is the condition of the spiritual activities, which condition is fulfilled in the finite minds into which it breaks. The facts which we speak of as given in actual experience are real as manifesting themselves in finite minds. Reality has this dual character. It functions in the thinking and volition of men as truly as in the form and the color of plants. Reality has a dual character, or rather it is natural-spiritual. We may distinguish but we cannot separate its elements. Hence mind and reality do not need to be brought together, and thought has not the impossible task before it of going out of itself to reality. It *is* by comprising the real: and the real exhibits its full and true nature only in the activities by which truth and goodness are attained. When mind appears on the scene the real breaks into knowledge as well as into music, and into moral lives as

well as statutes and stately edifices. It remains natural, but it is a nature with spiritual potencies that break out into actuality in man. He is nothing apart from it. He is continuous with it. He is effective as mind and will in the degree in which as subject he is saturated with its truth and purpose. For his purpose is a revelation and liberation of Nature's purpose. He is no external addendum, but her product. But when he appears, being her highest product, he recoils upon her, sublates her lower forms of being, assimilates them with and incorporates them into activities which are his activities without ceasing to be Nature's own.

There is a psychological problem for which, so far, no solution has been found. It is that of the *relation* of soul and body. Psychologists at present propose one of two theories. They suggest a panpsychism which converts all bodies into souls, or a parallelism between them and their phenomena. The former theory introduces more difficulties than it solves, and, so far, has not shown itself worthy of serious discussion; the latter confesses its failure in that it only states the problem and, in fact, offers no solution of it. If our criticisms have any validity, no solution of this problem is possible; and it is impossible because it contains a surd. It is like the problem of proving that $2 \times 2 = 91$, which would baffle all mathematicians; or of inventing a perpetually moving machine, which must baffle the physical inventor; or like saying, "Why should we be moral?", which must baffle the moralist. The mathematician, physicist and moralist who know what they are about will not ask these questions. Nor will the psychologist endeavor to *relate*—that is, to *bring* together in thought—what he *assumes* to be separate in existence. He will rather take to heart what Aristotle has said of such a dualism. He will regard the soul as the highest expression, the full reality, the ἐνέργεια of the body

—not deleting it, nor supplanting it, nor yet subordinated to it as a mere consequence or effect, but rather as that in which the body exhibits and realizes its full being, and in doing so proves its intrinsic spiritual potentialities. In man also we find exemplified always, not a soul plus a body, not merely natural or physical and superadded spiritual powers, but *one* being whose spiritual activities are at once conditioned by, and sublate, or take up, the so-called natural elements. The problem of the psychologist as at present stated is insoluble, because he is unjust to his body and ignores its function in all volition and thought, attributing cognition and volition to a mind in isolation, mind as merely subjective, of the existence of which there is no least item of evidence in any experience.

Man, like the cosmos, is nature at its highest and best, and nature is not a dead mechanism and mere opposite of spirit, any more than it is spiritual apart from mind. The beauty and truth and goodness which appear when man is upon the scene are not only his, but nature's also. And spirit does not dwell in it as in a dead husk, but is its own intrinsic power. This, it seems to me, is the view toward which recent thought is gradually moving. It is the theme and the inspiration of the greatest poetry of our time, from Goethe and Wordsworth to Robert Browning, and it is the aspiration of the highest morality and of the most elevated and reflective religious consciousness of the present age. It is the special mission of philosophy to demonstrate the validity of this view, and make good the truth of the one radiant ideal.

There are evidences that philosophy has entered upon this task. But the task is great and very difficult. It implies not merely revulsion from the consequences of the abstractions which have hitherto obstructed its path, but the most fundamental revolution of all the revolutions of the world of

mind. It implies a change of method. It must start from a different hypothesis and must therefore reinterpret every fact in the light of this hypothesis. I must content myself at present by merely indicating the main obstacles which obstruct its path as it enters upon its problem, all of them due to the abstractions which we have substantiated into contradictory opposites.

The first of these are logical, and therefore metaphysical also, or ontological. I acknowledge that it is precisely in its logical doctrine that modern philosophy has made its greatest advance toward the adoption of this point of view, which, in fact, is that of spiritual realism or concrete absolutism. Nevertheless, even at its best, it is not free from the entanglements which issue from the use of the external categories, which Kant called the Categories of the Understanding. That it is not content with their use and that it aspires to a better is illustrated by its appeal to *intuition*. Intuition is found to achieve what lies beyond the power of the understanding. It grasps things in their veritable unity: it does not obliterate differences, but it makes them harmonious or transparent—to employ its metaphors. It bridges the gulf between knowledge and reality, and brings mind into immediate illuminating contact with that which is. But it does this at the expense of all method. Its operations are mystical and miraculous. It explains by means of the unintelligible. It has no value except in so far as it expresses discontent with the external methods of "the mere understanding," which, after all, it cannot supplant and must merely supplement.

The method of intuitionism is too easy. It is like the optimism which finds that all is right with the world by denying or ignoring its unhappiness and wickedness. It cannot help until it turns back upon the topics of the understand-

ing, and reveals the unity within its opposites, and shows it to be intuitive in the double sense that it always grasps unity and is always in actual touch with the real. But owing to the domination of these external categories the judgment is still treated as if it were the result *either* of a purely analytic *or* of a purely synthetic process, and reasoning as if it were *either* deductive *or* inductive. The predicate is either attached to the subject as a new thing, or it is a mere repetition of a part of the subject. In the first case the judgment is a mere accretion of elements; in the second, a mere tautology. In the first case it cannot be true; in the second it can have no meaning. Moreover, both of these processes rest upon a false supposition as to the nature of the relation of the part of the judgment, as well as of the parts themselves. Their agreement is assumed to mean their identical and indistinguishable sameness—bare unity; their disagreement or negation, to be contradiction and repulsion. In no way, therefore, can either of these theories represent the judgment—that is, any rational opinion—as concrete; and the process of judgment as beginning in the subject with what is already a system, and exposing the nature of the system in the course of judging and reasoning, distinguishing its elements and deepening its unity by the same movement.

Again, on the epistemological side, the "that," or real being, of the object of knowledge is held to be distinct from its "what," or its qualities; and judgment is made to consist in bringing these together. And, further, as I have already indicated, knowledge itself is separated into forced abstractions, and the content is assumed to come from the data, while the form is supplied by the activity of the subject. The consequence is that knowledge and reality themselves remain in inexplicable opposition, and truth is in fundamental contra-

diction with itself. For it is assumed that to agree with or to represent the real as it is, it must cease to be as truth, and be merged in the real, or else be transmuted in an unknowable way by an unknowable Absolute.

But such results indicate the need, not of escaping from methodical thought by means of mystic and methodless intuition, but of recognizing that thought is always systematic and its object always a *One* in the Many, and therefore of ceasing to set the dualistic problems which baffle all attempts at solution.

The second main obstacle, and possibly the more serious in practice, may be called ethical. It is assumed, to put the matter as directly and concisely as I can, that the ethical world will disappear if man is not the genuine creator of his own actions, or absolutely spontaneous; and, further, that his creative power or spontaneity must mean that he stands apart and absolutely isolated from the so-called outer world. He is a *pure* subject, as represented by Kant, ontologically separate from all objects, and even from *himself* when he is the object of his own knowledge—his knowing self falling into the noumenal, and his known self into the phenomenal world. We are jealous, and rightly jealous, of our own intrinsic individuality, and assume that in order to maintain it we must hold the world, so to speak, at arm's length and extrude it. Let the outer conditions, and even our own past history, be what they will, we must at any moment have the power of acting upon it and from it in a manner that, for all computation, must be contingent. "Contingency," as we have seen, must be "let into the heart of things." The inner life shuts out the outer world; or if it shuts it in or comprises it, it is only in the form of "experience"—that is, of thoughts, feelings and volitions—and its realities become "phenomena." We have "gone back to Kant," and we still

dwell among his contradictions, for we have not gone forward from Kant.

Now I have no desire to minimize or to obscure in the least degree the privacy of personality, or the subjective and intensely individual character of all experience. On the contrary, there is no apparent excuse into which I would not follow the solipsist in this direction. All experience is in the fullest sense individual, and there is no such thing as universal experience in the sense that one finite man can think the thoughts or will the volitions of another. Every man's thoughts and every man's volitions are *exclusively* his own, and no other's; they remain his own even if it be true, as it is, that other men may know the same truth and will to bring about the same change.

When the idealist, in endeavoring to meet the evident objections to solipsism, affirms that a man's mind is not a particular thing, like his pocket-knife, but has a universal nature, which makes his mind one in intrinsic structure, subject to the same laws, active in the same manner as all minds, or as mind "as such," I have no concern in contradicting him. But such an argument does not obviate the difficulties of solipsism. However universal in nature a man's mind may be, it does not lose its intensely private and personal character, and all his experiences are his own in a sense that is exclusive. In other words, the *subjective, personal, private* character of experience remains, and every mind looks at the world with its own eyes. Were all men, like the gods, possessors of the real truth of all reality, their thoughts would still be their own; and were all human wills *one* with the will of God, they would still be personal wills and the moral perfection would be their own.

The reputation of the solipsist is implied in his own premises. There is no solipsist who in making an affirmative does

not consider that his affirmation refers to, and is an ideal construction or representation of, reality. He is expressing his own thoughts of the real, and his thoughts are his own. But, unless he confuses the *results* of his thinking with that *about* which he is thinking, and the object which he strives to comprehend with the products of his effort, he will not maintain that the real about which he thinks is also subjective. He cannot at the same time profess that he is expressing the truth and maintain that he is not dealing with *the* real. His thoughts, however subjective, have an objective reference, and however personal and private, they are his personal and private conception of that *which is*. Truth, affirmation, negation, judgment have in every instance this reference to *the* real. The reference is direct in every experience, and the reference is always to *the* real—that is, for each mind, to *only one* real.

Hence every solipsist considers that he knows the truth; and it is not possible to affirm or deny except on this presupposition. The question of agreement or disagreement is subsequent and secondary. What concerns us now is the universal and necessary character of every experience, however personal. The reference of a judgment is not to a private real; not even when he says, "This is only my opinion." Even that statement is a statement of a fact. And it is alleged that the result of the dealing of different minds is a different experience, or as many opinions as there are minds. Still, each mind in every affirmation refers to what is real, or to what his thought represents or misrepresents.

Nor can it be affirmed that each subject refers to a different reality, a reality infected with the illusions of his own thought. Once more it is the result that may be illusory, or merely phenomenal. And, as we have seen, the results of knowing cannot be the *data* of knowledge; nor have they

any existence except as ways of the activity of the cognizing subject. Phenomena do not constitute a class of existing things, over and above the subjects which know, and the reality which the subjects endeavor to know.

Thus every experience is bipolar. It is the living relation or interaction of two elements of a reality which is at once spiritual and natural. Knowing and willing is the act of the self by means of this world and of the real world. For no existence can refer to any other.

The question of the agreement or disagreement of the different experiences, or of any community between them, is subsequent and secondary to the reference of each experience to the real, which every judgment is. And it also concerns reality, which is capable once more of being rightly or wrongly interpreted. And the real is in this and every other case the criterion of what is held to be true or false. So that the reality also is assumed in every experience, in every act of cognition, to be bipolar. It is, and it is capable of expressing itself subjectively to the knowing mind. Reality, we may perhaps be allowed to say, expresses itself in many self-conscious foci and in many degrees of accuracy and fullness. But the presupposition of *the real*—that is, of one single reality—is as inevitable to every subject as the presupposition of his own existence.

When the solipsist, therefore, affirms that every subject has his own experience, which is true, he overlooks the fact that the object with which each experience deals or which it endeavors to represent is that which *is*. No subject can assume that there are as many systems of reality as there are interpretations of it; he denies to the experience of others that which is essential to his own and to the very possibility of experience.

It follows from this that there is one criterion for all experience, and one ideal. It is reality. It is by constant reference to it that he corrects and extends his own, and affirms or denies the truth of the experience of others: for their expressions of it are also objects for him, and parts of the reality which he endeavors to know. And the reference to the real is a reference to the Absolute—that is, to that which is all in all and exists in its own right. It is by their seeming congruence or incongruence with the presupposed whole of reality that particular opinions are called true or false. But this is as much as to say that reality is held to be a systematic whole, within which each particular fact has its own place and function. If we work to correct another person of error in any judgment, we do so by compelling him to choose between that opinion and his interpretation of that which is real. The admission of a new truth may compel us to revise our conception of the system of reality. A new hypothesis may carry with it a revolution in our view of reality; but the reality which is the aim of our intellectual attempt, and the criterion of the value of its results, is no new reality. It is not true, therefore, that there are as many *realities* as there are opinions of reality; although there may be as many interpretations of it as there are cognitive subjects. On the contrary, each subject is necessarily assumed to be from his own standpoint endeavoring to interpret *the* world of reality. Experience, false or true, has otherwise no meaning.

It is this truth that Spinoza expressed when he said that knowledge is adequate in the degree in which the subject of knowledge contemplates objects *sub specie æternitatis.* And the moral life of man—that is, his practical life when considered in the light of its ultimate issues—gives an interesting illustration of this truth. For morality also carries within at

all times this immediate reference to the Absolute. The action may be, and always is, particular in one of its aspects. But it is also a particularized universal. The right action is a specific affirmation, and the wrong action is a specific violation, of a Universal Good. The right action may be in itself insignificant—the mere giving of a cup of cold water; but being right, it is what is required in that particular context, and neither gods nor men can improve upon it. It is the particular reification or incarnation of the best. It is doing the work of God, in the language of religion. It is accord with the nature of things. And thereby it acquires inexhaustible worth and power.

Hence issues the dignity of an act which we call good, and the splendor which cannot be obscured. Hence also flows the sense of unconquerable strength which the moral agent always feels when he is in his duty. The nature of things is at his back. God is with him. His will is one with the divine. It must prevail. Its language always is, "If God be with us, who can be against us?"

Both in cognition and volition, therefore, both in knowledge and in morality, once we have freed ourselves of the fixed abstractions of the understanding, we find that immediate continuity with reality which *is* our own life; and the service of the true and the good, being the service of what is real, is the service of freedom so perfect that it finds nowhere aught that can limit or obstruct it. The service is fuller, the closer and the wider our communion with what is real; and the natural cosmos, in all its wealth, is not a limit but a condition of the life of our own spirit, and the living partner in all our spiritual enterprises.

HENRY JONES.

THE PROBLEM OF THE PHILOSOPHY OF HISTORY

THE THEORY OF CIVILIZATION

THE METHODS OF EXTENDING CIVILIZATION AMONG THE NATIONS[1]

I

THE PROBLEM OF THE PHILOSOPHY OF HISTORY

IN all the dominions of science, and especially in those relating to the human subject and dealing with first principles, there are questions—I will not say of eternal standing and controversy (because to say "eternal" is to anticipate an issue of which, in view of the future's uncertainty, we are not authorized to speak), but indeterminate questions which from the beginning of the known history of scientific thought down to the present have been treated by the different schools of thinkers very differently. Seen thus through the medley of systems and opinions, these questions give the impression of something which is insoluble and by all our processes of knowledge unattainable, something in regard to which it is useless to devote time and energy, since the solution arrived at will not give universal satisfaction, a sign that it is not truly scientific,—and in this, indeed, is explained the position of those individuals (by no means few in number) who, intent on the scientific requirements of precision

[1] Three lectures presented at the inauguration of the Rice Institute, by Professor Rafael Altamira, late Professor of the History of Spanish Law in the University of Oviedo, Director of Elementary Education in the Spanish Ministry of Public Instruction.

and exactitude, exclude such problems from the sphere of science and disdain and abandon their investigation.

In spite of such exclusion, the thinking classes of humanity (which are not limited to the professional scientists) persist in stating these problems and in asking questions relating to them or derived from them. These inquiries demonstrate that the problems themselves are a part of an inherent and natural curiosity within us, and are a necessity inseparable from the human spirit—at least as it has been constituted up to the present. We can say no more than this, for it should not be forgotten that all our observations regarding our own nature are based on what has emanated from a period of human life which may seem long, but which is short when considered in comparison with what that life may be prolonged to in the future. Our hypothesis, given the present nature of our intelligence, can never, however fecund the imagination, exceed the finite number of occurrences which embraces the known reality. As this limitation to actual experience is common to all the orders of our reason, it is clear that we are obliged always to work upon the basis of our mind as it now is and has for some time presumably to continue.

The curiosity which belongs to our minds as to-day constituted, then, inevitably causes at one time or another the same questions to be raised, and impels even the professional scientists to formulate them, notwithstanding the futility of previous efforts. But if all this is certain, it is not less so that some of them, although lacking solutions unanimously accepted, begin to show, amid the medley of opinions in regard to them, a certain general orientation or certain points of common acquiescence which signify their advance toward a more scientific basis, a surer and more satisfactory ground than that hitherto occupied. It is this which is occur-

ring with the question of the Philosophy of History, and to signalize and determine in regard to this question that general orientation and those points of acquiescence seems to me a service that would be of indisputable utility.

It will be useful, in the first place, as a basis of future investigation, as a basis of real progress on the road to a solution,—on a road which is, properly speaking, scientific,—since progress in the knowledge of things depends on the clarity and security of what has already been established. But it will also be useful for another reason, a consideration of a social character which professionals are in the habit of overlooking. I refer to the influence exerted by their doctrines on the masses among whom these doctrines become translated into lines of opinion and of conduct. For a *scientist* that which alone is of importance and alone is worthy of attention is the truth or the error of a theory, and from this standpoint he may, and does, neglect all theories which appear to him untrue, discarding them from that which merits his attention. Thus, in the Philosophy of History a *providentialist* will reject and disqualify the doctrines of a *rationalist* or those of a *positivist*, and *vice versa*, but neither one nor the other will be able to prevent these conflicting doctrines from influencing large numbers of people and guiding them in not a few questions of their lives. With equal reason the contrary positions of those who admit a Philosophy of History and those who deny such a thing collide with and annul one another, but both are powerless before the fact that many people will accept one position or the other; and as, in the long run, that which matters is that which influences the masses, the conflicting theories which claim the solution of these indecisive questions come to possess for the sociologist, for the practical man, and for the historian himself a value which is at best only equally pro-

portioned to the scope of their diffusion and to the force of the conviction they produce. All, then, which may tend to eliminate divergences, discover points of contact, or, better expressing it, to intensify in the public mind the consciousness of common affirmations in what has arisen from distinct starting-points and systems,—affirmations which have not, perhaps, been realized by the majority,—is preparing the way for an ever greater homogeneity in thought and action.

Now, of late years, in the sphere of the Philosophy of History, owing to the discussions which the actual statement and formulation of the question has produced, there has been a fairly concrete determination of factors and a clarification of ideas relating to the subject. Neither movement has descended to the great sphere of those who are non-specialist but cultured sufficiently to produce in it a favorable change of the same character; but this same lack of correspondence between the scientific position up to date and the sediment of antiquated and already scientifically rectified ideas which have passed down into the masses as accepted knowledge renders all the more necessary that labor of diffusion whose first effect has to be the clear determining and sizing up of fundamental opinions and authorities. The necessity is all the greater in so far as one may consider included in the masses the large number of persons whom, at first sight, we should qualify as cultured, persons who have obtained university degrees and who undoubtedly possess wide information and clear intelligence. Thus, I have heard my book "The History of Spain and the Spanish Civilization" described as a work of historical philosophy, although it is simple and unmistakable narrative, simply because it contains, with the usual chapters on political history, others on what has been called *Kulturgeschichte*, or internal history.

This very common error signifies not just a vagueness in the conception of the Philosophy of History (vagueness there is as well, and in due course we shall examine it), but an absolute disorientation in which it is impossible to form any argument whatever or even make one's self intelligible to those laboring in the fallacy, for the simple reason that while employing the same name, they imply something wholly different. Let us begin, then, by rectifying this error, that it may once and for all be deleted from the public mind. Every history-book is pure narrative if it limits itself to relating facts. Although it may embrace in entirety every sphere in the whole life of a state, including the history of its thought in the various orders of the sciences and in those treating of human questions, it is not a book of Philosophy of History. It may be the work of an historian who does not believe that science possible or regards it as dissevered from his professional mission: his ideas in this respect will not in the least have been invalidated.

Equally common with this error, and perhaps more so, there is another one more difficult of eradication and of graver consequences for the reason that it comes near, apparently, to the actual field of philosophy itself instead of being plainly and at a glance outside of it. This is the error in which, in the name of philosophy, is inferred every generalization regarding historical facts. To those laboring in this error everything of a general character that may be gleaned from an individual history of concrete facts—the character of an institution in a given epoch, the dominant and central current in a series of events, the distinctive feature of the history of a state, the trajectory and orientation of an order of ideas—is Philosophy of History. But as, apart from such works of erudition as are purely concrete and monographic, every historian must generalize without de-

parting from his own material of facts, it may be deduced, according to this criterion, that there will scarcely be a history-book which is not philosophical. A book which summarizes in a great compendium, a great "synthesis," as it is commonly but erroneously expressed, the facts of a period, of an age, or of a state, and popular lectures which epitomize the great results of detailed investigation, would be Philosophy of History when, in general, they are rigorously limited to the field of what is narrative—that is to say, purely historical. The celebrated lectures, for example, on the "History of Civilization in Europe," by Guizot, do not in any way possess the philosophical character, although their eloquent expression and the reflections and opinions often to be found in them which do not cover a ground that is, properly speaking, historical, added, moreover, to the lax and careless criticism of contemporaries to whom all this justly came as something new, led to the lectures being designated by many as philosophical. Generally speaking, one may affirm, on the contrary, that every generalization about facts, while it remains a generalization, and however abstract be its character, is not philosophical. What always result from it are facts, very general, very comprehensive, but, in the end and in the long run, facts. Laws themselves, or the course they follow in a more or less extended period, are likewise facts, although of an abstract character. They express what is the line and orientation of individual happenings; they do not explain them *philosophically* or, to be more precise, *metaphysically*.

I have now just enunciated what, in my opinion, is a basal quality in the Philosophy of History; but, to avoid confusion, it will be necessary to define it. Every *explanation* of facts is not a philosophic explanation. Naturally it is not so when it treats of causes which are directly or indirectly his-

torical—that is to say, determines temporal origins and precedents, the factors behind an appearance and effect, the necessity of a phenomenon in a given moment. No one will describe as philosophical the explanation of the collapse of the Invincible Armada, an explanation which is entirely confined to the most concrete facts and as historical as any in the world; nevertheless many other analogous explanations of greater or less significance than the above are still described with manifest equivocation as philosophical. The explanation of the Hellenic genius and culture as a consequence of oriental origins, of such and such influences derived from the geographical situation of that people, is equally not of a philosophic character. All such explanation moves entirely amid temporal causes and on a ground which is purely historical, however vast and general its embrace of the concrete facts and data. For the explanation to assume a philosophic character it must treat not of temporal but of permanent causes and must inclose facts in a metaphysical impulsion and causality outside of the field of history. It is not without purpose that the science under consideration is called Philosophy of History (of human history, it is clear), which means that it is a philosophic science and ought to be treated according to its nature and not on historical lines. The antagonism between the Philosophy of History and the History of Philosophy, which has been shown and explained by certain schools of thinkers, defines thoroughly the distinctive character of each of these sciences, notwithstanding that the terms employed in them are identical: the different relative position of both terms in each of the two cases signalizes plainly the opposition in question.

It is necessary, then, to abandon all false conceptions of the science concerned with these reflections in order to place ourselves in the actual field with which it corresponds. Once

settled there, the discussion of the problems belonging to this science becomes disentangled because we know now the value of the words employed and are no longer in the plight of discussing indefinitely and without understanding one another two things which have nothing else in common but the name we give them, a name which is applicable only to one.

With this point settled, it is now possible to propound the first question of the Philosophy of History, which is precisely that now most under discussion in our times—to wit, the possibility of the science in question. In any case this would have to be the first question to be discussed and to be solved; for, what would be the use of fantastically pursuing the principles of a science devoid of all reality—that is to say, impossible? We should be involved in a labor that is not only useless but pernicious, through the false ideas that would be disseminated.

Before examining this question and expressing in regard to it, if necessary, a personal opinion, it is important to separate it from another which is often confounded with it, the one prejudging the other with its own solution. It is one thing to question the possibility of a Philosophy of History, be what it may the field of science in which it is established, and it is another thing to inquire if historians as such are capable of creating it, or even merely if its existence concerns or ought to concern them. The distinction between these two questions is all the more necessary in so far as many treatises have dealt only with the second of the two, and presumed, in the solution of it, to have solved the first and fundamental question. In reality, the second question, as it is commonly propounded, is beside the point. If the Philosophy of History, given that it is possible, is a philosophic and not an historical science, it clearly follows that it devolves not on the historian but on the philosopher to for-

mulate and clarify it. It is legitimate and comprehensible on the part of the historian to declare himself as such incompetent; to refuse to employ his energies in the investigation of an aspect of human history which does not concern him; and to demand the requisite time and energy for what does. For this reason it is a strong position which has been adopted by those who, under the title of historians, refuse to busy themselves with that problem, and even regard it as pernicious that it should be mixed with those peculiar to history; basing their opinion either on the supposition that the character of historical knowledge fundamentally prohibits a philosophical explanation, or on the supposition that the actual position of historical science does not as yet authorize it.[1] Observe, however, that the majority of those of this opinion admit that outside the sphere of history, in the field of other science, the problem is legitimate and is one that may be formulated and considered. If he wishes to abide in his own sphere, it is not the professional historian who will study it, but of the results of the investigations which others have accomplished he will be able to take advantage.

It is clear of course that this does not exclude a historian from studying the Philosophy of History, just as he may be interested in astronomy or any other science, nor can it be denied that in the fact of his being a historian his preparation in the study of the problem is the more adequate for a deep penetration into a given one of its aspects.[2] The natu-

[1] An exposition of the situation of that question to date is to be found in my book "Questions of Modern History" (Madrid, 1904), Introduction and Chapter III.

[2] One of the scientific weaknesses in many authorities on the Philosophy of History who would be styled classical—and even of not a few modern philosophers—consists in their not being or not having been sufficiently *historians;* that they do not see the problem in its essential historical perspective; and that they have failed to fulfil that exigency which Dilthey ("Emlestung ni de Gentenvissenschaften") formulated, saying: "The thinker who takes as his object the historical world, ought to be intimately acquainted with the immediate material of history and should be entirely the master of his medium."

ral supposition, in fact, is that it will be the historian who will be interested in that problem because the constant vision of the historical material will continually produce in him a desire for an explanation transcending the mere facts themselves; and, in any case, as a man of intelligence he will be brought up against the problem, though he may not embark on the solution of it. Nor, moreover, in the preceding affirmations relative to the independence of position between the scientific sphere and the philosophical is there any denial of the intimate bond which unites them, and in virtue of which not only does the philosopher require, as was said, to be master of historical matter, but the historian will find in philosophy a force which, although it is not his business to create it, will help him in the handling of his data.

Now, it is quite another thing to state the objection in regard to a Philosophy of History to the philosophers themselves, basing one's position on the present status of our knowledge of the history of mankind. Such an objection—distinct from that embodied in this argument against the possibility merely of the "historians" creating a Philosophy of History—may be based on an affirmation of that strict interdependence in which, we affirm, both terms are to be found. Kohlen has expressed it in a decisive manner with reference to the Philosophy of Law: "Without a universal history of law a true juridic philosophy is as impossible as is a philosophy of humanity without a similar history of mankind and a philosophy of language without linguistics." This, then, denies for all men the possibility of a Philosophy of History, although only so long as it fails to fulfil that fundamental requisite of previous acquaintance with the facts in all the amplitude necessary that it may be possible to philosophize about them; and, to my mind, this is the strongest objection

that can be opposed to the present possibility of a Philosophy of History.

As a matter of fact, it is only by the force of habit and the suggestion exerted by those books (that is to say, the doctrines elaborated in them and the systems formulated, which give the false appearance of something perfect and conclusive) that we say and even believe that we are acquainted with the History of Humanity. Certain it is that considerable in range as is our historical information, and although that information has augmented so vastly in one century in regard to the above branch of history in particular, and become perfected in certitude and thoroughness, there still remains much for us to learn, still many points of obscurity and vagueness, many facts and theories in suspense; and that on a basis so imperfect any philosophic structure will be flimsy, collapsing at the least pressure. For, if we do not possess our facts securely and in entirety, how can we build upon them anything stable or secure? To the immense force embodied in this argument is due the most useful and fruitful of the results which modern criticism has produced in the discussion of the problem now before us. By dint of this argument has been demonstrated the inconsistency between systems relating to the Philosophy of History constructed *a priori* by writers who, in not a few cases, are ranked among the great. This failure was merited, as merited is the smile with which, to-day, we regard, for example, that infantile endeavor to inwrap the history of mankind in periods or ages of development which limited the future and closed up the eternity of life. In drawing up a clear table of all in these systems which was warrantable and final, the criticism of the professional historians has constituted a service to science of immense value, clearing the road so that it should be unobstructed by pseudo-scientific—though some of them

colossal—structures which would render it difficult to make the labor of the future step by step and in certainty. It is true, however, that it has produced also a pernicious skepticism in many people who, with the precipitancy so natural and difficult to check in human nature when a definite conclusion is arrived at and a judgment passed, have confused the breakdown of the Philosophy of History as interpreted by certain authors with the total collapse of the whole science. To convince the public of the error of assuming the second issue as a consequence of the first is in fact one of the duties of men of science in the social aspect of their labor.

Let us return now to the starting-point of these considerations. To deny the present possibility of a Philosophy of History because we do not as yet know enough of the history of mankind is not to deny its possibility absolutely and forever; agreed, however, on this point, the affirmation which has led us to it reappears and confronts us. We are still at grips with the fundamental problem. In short, if it is proved that it is definitely impossible for us to arrive at that initial historical knowledge which has to be the basis of a scientific philosophy regarding it, or if it is true, as many believe, that historical knowledge is incapable of scientific qualities and even of precision and of certitude, then to philosophize about it will be eternally impossible. The problem, therefore, is transferred to another ground and obliges us to discuss previously all those questions alluded to, and which in our days cover, as is known, an extensive literature. From the discussion as to the degree of generalization which is possible in regard to facts about humanity (a discussion maintained on the extreme wing by Xenopol, who denied that there could be any generalization), to the transference of history wholly and solely into the field of science, the series of minor problems presented in the different opinions upheld by the

specialists to-day require to be tackled and cleared up in order that we may either be free of all incubus in the affirmation of a Philosophy of History or else abandon the dream of its possibility. It would be long and wearisome here and now to enter on this task which I have already elsewhere accomplished.[1] I will refer only to the conclusion I there arrived at, and take my stand upon it under the plea of a personal opinion. The doctrine may be thus epitomized: In the present situation of our knowledge relating to these questions, and of the opinion of men of science respecting them, there is a decided weakness to be observed in the arguments employed to deny the scientific character (the possibility of such) in history, either because the general conception of science renders it possible to-day to state the problem with a different meaning to that of Aristotle, or because it is not so certain as is commonly believed that history is confined purely to the observation of individual facts, forming itself into a narrative without any generalization (of a more or less abstract character, that is, as all generalizations are), in which each fact conserves its unique and differential characteristic and only on the strength of it is mentioned. For myself, personally, however, the crux of the problem is not in whether historical knowledge conforms or not to the Aristotelian definition of science, and whether it is susceptible to abstractions of greater or less amplitude, but in whether it can attain those qualities of truth, clearness and certainty which distinguish scientific from vulgar knowledge. If to the scheme and elaboration of true, evident and certain knowledge which has as its objective the facts about humanity in time and space (and derives from that objective its own internal coherence) is begrudged the denomination

[1] In the book mentioned previously, "Questions of Modern History," Chapter III, No. 3.

"scientific," the question at issue is solely the question of a name. What matters is that our knowledge of man and of the manifestations of society in past ages shall arrive, by means of a rigorous employment of the critical methods of investigation, at being as certain as our knowledge about Nature and the facts concerning her, though neither one nor the other, either to the observer or to the experimentalist, delivers the totality of its abundant and (from day to day at least) mysterious contents.

The objection, then, which, if valid, would make it impossible forever, through lack of a foundation, to philosophize about the history of mankind, possesses no scientific authority for opposing an insuperable barrier to this philosophic aspiration; but it does serve most effectively to moderate impatience and to check precipitancy in the task of solving the main problem, showing the connection between this problem and many questions of importance still under discussion, revealing also its complexity and suggesting that even on the strong basis of a personal conviction rooted in the feeling that a right solution is arrived at, we are to preserve the judicious cautiousness which is characteristic of the truly scientific mind, and which safeguards against the possibility of error and makes us respectful toward contrary opinions. All that may avoid that suspicious simplification of a problem in easy terms—only subjectively arrived at while the problem itself is divested of many elements inherent in its complexity and which we fancifully qualify as incidental—and that provides us with the maximum quantity of proofs in support of our opinions by probing them and developing them with every kind of verification and analysis, will become a guarantee in support of our conclusion and of the doctrinal fabric we erect on it. It is for this reason that I have been explaining and examining the principal

objections to a Philosophy of History and the errors and confusions of thought in regard to it which draw into a distinct field—and one conducive to confusions—the interpretation of the name.

Over and above all this cautiousness and reservation, however, stands out one fact which even the most decided antagonist of a Philosophy of History has to recognize, not only as a reality but as a thing of importance and significance. This fact is the persistence in the human mind—in every man who thinks at all about the world and about life—of those fundamental interrogatories in regard to the actual problem of the philosophy in question.

It is true that, in view of the potential immensity of future history and the paucity of that at our disposal (as was observed not many months ago by your compatriot Professor Sloane[1]), the persistence in humanity or in great masses of it, of a given idea or preoccupation does not in itself always signify that the notion or ideal in question is consubstantial with our nature, since it may well be a survival, a vibration from primitive stages of thought not yet modified, and to which, in fact (in that relative value of time), we are chronologically very near. For this reason it is not a plausible argument in support of the necessity of an idea or a belief that for many centuries down to the present a more or less considerable number of people have supported it and held it to be something fundamental. The future may wholly disillusion us. But if we ascertain that a definite idea or an ideal exists throughout mankind and is the stronger in a man according to his degree of culture—in an inverse relation to other spiritual phenomena, which exist principally on a sentimental basis and are rooted above all in the uncul-

[1] "The Vision and Substance of History," address delivered at Buffalo, New York, December 27, 1911. Published in "The American Historical Review," January, 1912.

tured masses or where culture is incipient—we have a very powerful argument in favor of its essential necessity for us. It is this which occurs with the problem of the Philosophy of History. Be it with a clear understanding of their meaning, their classification in the Encyclopedia of the Sciences, or be it without ever suspecting the relationship they bear to that, great masses of people are to-day, as in the first stages of civilization, formulating questions which correspond to the fundamental problems of our science; and each individual unit in those masses answers these questions from the point of view of a religion, a system of philosophy, or simply that of a common sphere of culture which finds reflection in himself or in which he has been educated.

It is true that many people pass through life without experiencing a moment in which those questions flash before their consciousness, because the material occupations of the daily struggle for existence leave no room for attention to other questions. It is equally true that among those who have broken free from this material incarceration, and even among those who move by custom in an intellectual circle, these questions pass often enough like swiftly flying sparks rapidly extinguished, or do not acquire that standard of importance which is given to a question as the result of deep preoccupation. For a long time, owing to doctrinal considerations arising from the predominance of certain philosophic systems (philosophic although some of them discountenance philosophy), there has existed an indifference and an apathy on the part of many people in regard to those questions. Although there has been a reaction in this respect, it is a fact that the number is still large of those who fail to appreciate their urgency—a fact, however, which depends on general causes traceable to the conditions of our modern life. The feverish activity, the superficiality and

show in which the majority exist, cause our moments of privacy and meditation, of communion of the spirit with itself and of self-examination in regard to life, to become more difficult and rare. Distracted by the outside spectacle, we lose the habit of self-examination and become deaf to the promptings of the soul, and often enough we pass through life in ignorance of the exalted curiosity within us. At times, in moments of brief solitude and thought, these questions suddenly appear to us, but the intellectual effort required in pursuing them, and the time they would demand, make us shy and half afraid of them, with the result that we suppress them and continue as though in ignorance of their presence, until, in another moment of doubt, anguish, discouragement or pessimism in which the mind has nothing to fall back upon or other resources but its own, they reappear before us, without, however, our ever possessing the hope of finding time or opportunity for their consideration and their answer.

Such a state of inattention to the problem is not enough, then, to deny that it exists; this state of mind, on the contrary, continually affirms the problem as a presence. Whenever we wish to hear its voice, it is with the utmost clearness that the voice echoes, and this in itself will be enough to guide us in the circumstances.

The historian derives a knowledge, or what he believes to be a knowledge, of the principal facts concerning the history of mankind; he traces the rise and fall of the great empires; he describes in its separate stages the process of civilization, its oscillating and, at times, contradictory movement, the advantage to one state of the labor of another which it resumes and carries on, the things which have been accomplished in modern times, and the trajectory and law of development of institutions and aspirations regarded as fundamental in importance; and then, over and above all

this remain those same great, disquieting questions which embody the whole program of the Philosophy of History: Where and toward what is mankind traveling? Is there a goal of which, at present, it is ignorant, but toward which is moving the central current of its history? Is it being impelled toward that end by something beyond and transcendental to it? What is its significance and value in the whole, in the general process of the universe? Is it the creature of chance, or has it an orientation and direction? And if it has, can we deduce that movement through such of the facts about humanity as we have knowledge of? Does there exist in the actual conditions of its life some other foundation than the corner-stone of history? And, following from all this, what state is it which marks or is to mark the triumph of that history, the culminating situation most nearly approaching and conforming to the purpose of the universe? Is it possible to define and predict for the future some main path for man, or is the Philosophy of History ever restricted to the limits of the present? Of the utmost clarity for every one engaged in the investigation of those questions which history, deeply contemplated, raises, must be the real and logical hierarchy which exists between them. Not all are on the same level, not all are equally far-reaching, and if I may use a phrase which is unscientific and inexact but which well reflects what would be thought by an uneducated person (that is to say, by the majority of people), they are not all equally philosophical, but some more so and others less. This question of a hierarchy and of a relative importance possesses a greater significance than would at first sight be imagined, because if we regard it as a proper and well-founded one, it at once brings us to the point as to whether or not the professionals, the writers who have propounded scientifically the problem of the Philosophy of History, have

grasped in fact the whole and entire problem, or whether they have limited themselves merely to the study of some one or several of the questions it embodies, and perhaps to some of them which, compared with those embracing the main object of the science, would be called secondary; and more than this, we are even led to the question whether it may not be the case that, while preoccupied with what they regarded as the real problem, they were not confining themselves, through an error of perspective, to aspects of history quite general and comprehensive in themselves, but above which they have never risen, never attaining a transcendental vision in the true philosophic field to which they were aspiring. I am not far from thinking that it has been thus in the majority of cases, at least with those great systems which have attempted a fundamental revolution in the Philosophy of History. I do not allude by this to the observation, continually reiterated by the critics and some of the most recent exponents in the matter, that the majority of these systems, if not all of them, losing sight of the complex nature of the problem, have given an ingenuous explanation of the History of Mankind to which is owing their failure or insufficiency. I refer to that which, apart from the degree of comprehensiveness in the problem they embrace, it is impossible to ask in regard to whether those systems embark on the true problem of the Philosophy of History, on which problem depends a series of others to be called consequences, or whether, on the contrary, it is not from one of these selfsame "consequences" or minor problems that they have arisen, the minor being mistaken for the greater problem in whose solution rests that of all the others. That this equivocation is clear in Montesquieu, in Rousseau, in Voltaire ever so much more so, and in other authors of an analogous scientific standing in relation to the Philosophy of History,—

that they failed to get abreast of the question and seriously tackle its solution,—no one will deny. But even with the great masters of the school, the same doubt is legitimate, and the decision may be actually against them. Will it be said that Herder, notwithstanding the discrimination with which he subordinated to the more general standpoint those secondary questions which were almost the only preoccupation of his predecessors in the century, actually raises in his problem of the factors and issues of the History of Mankind the real and basic question of the Philosophy of History? Was it approached by Kant in his own explanation of human progress—that is, the solution which is offered to the conflict between individual liberty and the general welfare—in the State? After this is there no room, even when the Kantian solution is accepted, for questions regarding the metaphysical problem of the plan of history, questions above and beyond the antagonism of individual liberties among themselves—that is to say, questions of a more general and comprehensive character, by the side of which the above is subordinate and over concrete? And in spite of the incontestable grandeur of the conception of Hegel, are we not left, perhaps, with the impression that in reality it lowers and depreciates the problem and denies it what should be a higher point of view, in which the development of the moral conscience, of freedom, and of the functions of the State becomes subordinated? The observation of history and its mode of development, and the interpretation of it exclusively from the viewpoint of a standard of ethics, notwithstanding a metaphysical quality, is yet something which too nearly approaches a broad but, in certain respects, very concrete vision of historical development which allows a vaster and remoter problem to float above it. Yet clearer is this in Comte and his disciples, and in Marx and his, the character of whose

philosophies is purely an analysis of the factors behind the phenomena of human history, factors which only explain these phenomena in a secondary manner. Even in the acutest and most comprehensive of these systems the mind is not left satisfied as when one has set hands on the real solution to a problem; it feels (and I say it without wishing to depreciate the value of those investigations and the clear light they have thrown on the movements of mankind) that there is something still wanting, something greater which remains unanswered, and which, if answered, would respond more fully to aspirations, properly speaking, philosophical.

I regard as scientifically legitimate this dissatisfaction of the mind even with the profoundest and minutest analysis of human progress. I am also of opinion that the problem of the Philosophy of Human History ought not to be wholly limited to the two questions formulated by Herder,—on the value of that history and the conditions in regard to its development,—since, although, in the consideration of the latter question, there may have been a glimpse of the ultimate and basic problem, the systems soon settle down into a mere analysis of conditions and a generalization about the facts of history which is secondary to the main problem. . . . That which cannot be described as an explanation of human facts by other facts of a like nature (they may be as general and fundamental as you like, but that does not affect their nature) cannot be described as history; and thus, what has by some schools of thinkers been called the "anatomy" and the "physiology" (or the "psychology," from another standpoint) of human action, is not Philosophy of History.[1]

[1] It is in not passing from that narrow standpoint that those claiming to have construed doctrines and systems of a Philosophy of History have been able to introduce and discuss the question of the anticipation of future history. In the concrete conception of this question it has been affirmed: "Humanity, in the future, will act in such and such a way, and attain such and such standards of civilization and development." The question is neither

And now, in conclusion, there remains this culminating question: Does there exist any actual reality and basis corresponding to that aspiration of ours towards a transcendental explanation of what is a greater problem than all those scientifically formulated until now in the so-called Philosophy of History, or is it a pure whim and caprice of the spirit that is never to be satisfied? To this question I do not believe we can provide at present a scientific answer; but I should point out that neither our present nor permanent impotence regarding the solution of what is an idealistic problem can banish that problem from the mind, which continues to formulate it as an aspiration that is ineradicable and to which it is forever hopeful of finding a solution.

And lastly we should remember, in order that the logical statement of the problem may leave no loophole of uncertainty, that the questions in which we embody the main substance of the Philosophy of History do not, in their formulation, prejudge an affirmative answer, nor is such an answer an ineludible necessity for their existence. Although our answer to all these questions were in the negative, they would continue to be problems present in our minds—so long, that is, as the answer is not indisputably a scientific one; and even if it were, it would, none the less, be legitimate material for a Philosophy of History as real and settled as if it answered in the affirmative those same interrogations which for the majority of men correspond to a desire, latent but ineradicable, to see explained in an ordered, rational and scientific method, according to the general plan of the whole universe, the Life of Man.

permissible nor can it be included in the field of the Philosophy of History. Thus, Meyer is right (in his "History of Antiquity") when he judges that such predictions are impossible, since in that which is generally referred to, the individual element predominates, escaping all prognostication; and affirms, always from that standpoint, that history only allows of comprobation, and not of any fixing of the future.

For this reason the essential necessity of a Philosophy of History depends neither on a special solution of its problems nor on the actual possibility of a solution being afforded them. It arises principally from the presence of the problem in our minds and from the corroborated fact that the highest expression of what, as concerns our history, is called progress, consists in the awakening of humanity to the idealistic quality behind its actions, of the things it is accustomed to perform in ignorance of their value and significance; and in the guidance of his life by man, ever increasingly, through the medium of that consciousness and with an ever clearer vision of the "why and wherefore" of things. To assist, by due attention to this problem, in promoting the study of it, and, some day (whenever that may be), the solution of it, is more reasonable and human than to bang the door upon it with an *a priori* negative against its possibility, or than to belittle and discard it.

II

THE THEORY OF CIVILIZATION

HAVING tackled the main problem of the Philosophy of History, we should now ascertain what practical issues have arisen from the study of those would-be philosophic problems undertaken by the specialists, and what, in this connection, deserves further attention.

We saw, it will be remembered, that all these so-called systems of a Philosophy of History, all the interpretations of this science to which the above name has been arrogated, have been limited, in reality, to the scope of history, transcending this field only in brief moments of the investigation or in theological conceptions which we are not concerned with. But, although none of the systems in question may have afforded a real basis for the science they proposed, they have served, on the other hand, in no small measure as a means of deepening our conception of history itself and of widening our vision of it, while revealing all that is embraced in what is called historical material, determining the more important and decisive factors which (some of them in distinct periods or epochs, others at all times) are at play in the action of mankind. In spite of the exaggerations which in most of these systems are conspicuous, and in some notorious, it is an undeniable fact, once having discarded the false, unilateral pretension common to nearly all of them and transferred them to their own sphere of history, in which such of their investigations as are of value may be developed, that to the science of historiography they have rendered immense services, at once widening its horizon and

revealing the complexity of human labor which each one of them has studied in an aspect not infrequently as real as it was hitherto unrealized. We can appreciate the positive fruits of these investigations on observing the great difference between our method to-day of conceiving and writing history and that which prevailed some centuries ago; and even, it may be said, between the historians of the seventeenth century and those of the nineteenth. The methodologists, advancing theoretically ahead of the historiographers (the latter exerting themselves to fulfil the exigencies of the former and turning to account the suggestions obtained from the "philosophers" of history, or at times actually raising systems of their own by way of experiment and illustration—*e.g.*, Taine), have paved the way for our modern conception, ever becoming wider and profounder, of human history. And this labor, which has enabled us to elucidate man's past with ever increasing vividness and with a keener penetration of its meaning, is a solid basis on which we may hope to find an answer to several of the questions which are suggested to us in the contemplation of that past. Starting, then, from such a basis, with all due prudence and a rigorous employment of those critical methods of investigation which are essential if one is to avoid wandering into fantasies (fantasies, though, not necessarily philosophic in pretension), we shall be able often enough to arrive at conclusions of real scientific value, while other hypotheses will serve as a scaffolding for subsequent investigation. And as this field embraces what is positive and certain, and all that we are interested in, deriving from a great portion of the moral and political applications of historical knowledge, it is our business to approach and examine it rather than sacrifice it to the lure of a higher and remoter explanation, which, even if possible, in no way excludes the above study nor renders it

useless. Within purely terrestrial aims and limitations of which we ourselves are cognizant—that is to say, human aims, of human interest—while equally, also, in our legitimate anxiety to understand more fully the way in which, from one moment to another, a community conceives its task and function in the world and tackles and solves the problems which are its own, what is of immediate consequence is the investigation of all those historical elements which may afford us the knowledge we require and establish our conclusions; for, in the long run, that in the study of history which descends among the crowd and interests it, is the critical estimation in which, as a result of historiography, each historical epoch and entity is held, and the estimation of the general movement of mankind in regard to the question of social development or "progress" as we define it, though with error, since a meaning is, in this connection, attributed to the word which implies actual betterment, improvement. Clearly such a point of view will be a very subjective and uncertain one, since it entails that each epoch judges past ages according to its own social and moral criterion, and this criterion is not eternally the same; but there is no other standpoint open to us, nor can there ever be another, with the result that our only course is to reconcile ourselves to the manner and circumstances in which these questions must be considered and in which they have attracted us. If we are bent on verifying history ever more widely and more precisely, it is not for the simple esthetic pleasure of knowing things, of reading or hearing narratives as children read and are told stories, but for the object of explaining to ourselves why men have acted in such and such a manner, of apportioning their responsibility and forming our opinions about their conduct. Whether or not we are conscious of this object, it is this which is the initial force behind our curiosity regard-

ing history, our researches either aiming at an explanation and justification of that particular national or political aggregate to which we may belong, or a criticism of the others foreign to it; and the judgments and appreciations which are left over in our minds from these researches are factors which determine the conduct we pursue in our own private sphere of action and in our relationship with other minds. From a broader and more disinterested standpoint, above mere national distinctions, we are desirous, also, of learning the road humanity is taking in what we suppose to be a definite trajectory toward a more perfect state; what actual advances have so far been achieved; and what are the surest means, such as the experience of history has confirmed, for guaranteeing and augmenting this improvement. And here, in this higher sphere, that which in the other province of concrete criticisms and estimations regarding given communities amounts to a conflict between national influences and interests, is now a conflict of general theories about life, of distinct methods and systems of organization, a conflict for priority between such and such factors in the life of man which, on the supposed justification of history, claim, in regard to that life, the right to be made the controller of it.

And this practical issue which men deduce from historical investigation adds a new value to it over and above what it represents in the sphere of pure speculation, and is one of the motives on which its study may be justified against those combating it, in the name of a common utilitarianism which is eternally in doubt but forever reappearing.

The investigation which is proposed here embraces the two points of view referred to, responding to the suggestion of the theme taken by Dr. Edgar Odell Lovett, President of the Rice Institute, for the present inaugural celebrations. We shall discuss first of all, as a general question, the prob-

lem of the history of mankind, following this with a special investigation into the Spanish backgrounds of American history.

The general problem of human history, as we shall interpret it, is the problem of "civilization," or, as it is also expressed, of "progress." Is the process of human civilization something continual and indefinite? Is civilization a thing which is permanent, transmissible, and which grows in successive stages? What is the actual stage of civilization we of this era have arrived at, taking the criterion of humanity in general, or of those we regard as the most highly developed groups of it? These are the first questions which the problem raises. By what means is civilization produced? What, in consequence, is the procedure to be adopted in order to insure and further it? These are the questions which immediately follow.

Now, as regards both series of questions the answer is naturally to be sought in history, since civilization is an historical fact. This historical fact, however, has been translated in our minds into a conception, or, to define better this appellation of "civilized" which we apply to certain ways and customs, certain principles of life and conduct adopted by men in their relations with one another (as distinct from other ways which we should not describe as civilized), into an idealistic criterion—a classification, that is, of the particular conception and ideal we stand for. It is thus that the first question to be considered and settled is the question of the exact categorical meaning we shall agree upon for the word in which are embodied all those different principles and customs—that is to say, the first question to be answered is: What is civilization? As regards the common meaning of the word, the vague acceptance accorded it, such as is usually

accorded words, and which admits of their use in conversation and even in books without the necessity, on each occasion, of explaining them, the answer to the above question would appear simple. Yet, nevertheless, as occurs in so many other cases when one endeavors to fix the meaning of a term, there is not merely a variation in the acceptance of this word among different people,—a variation, let it be noted, singularly conspicuous among professionals and specialists,—but often enough an utter contradiction.

A rapid inquiry into the principal interpretations of the word "civilization" will enable us to become master of this difficulty on which, sooner or later, one inevitably stumbles. . . . We will discard, at the outset, that acceptance of the word, common in modern historiography and prevalent as early as the eighteenth century, according to which the history of civilization (*Kulturgeschichte*) is held in contraposition to "political history," or which also makes the term "history of civilization" synonymous with the *internal* history of communities in opposition to what is external history, and comprehensive only of political facts, or rather that section of political facts most superficial and least permanent in character.[1] Such a contradistinction is illogical because there is no justification for it in fact. The history of man has not evolved in this fashion, divided into two fundamentally separate branches of equal magnitude; and, moreover, there are no grounds for maintaining that many—or, in fact, any—of the facts of political history are extraneous and immaterial to the sphere of civilization. . . . Rid, however, of this illogical distinction, we are still faced and obstructed by the twofold difficulty that among the definitions of civilization offered under the title of scientific there

[1] On this question also reference should be made to the book previously mentioned.

are scarcely two that coincide,[1] and that the criterion by which a community judges its own and other civilizations is not common and the same for all—at least, that is, when it is a question of fixing the basic and essential characteristic of the civilized state.

As a first group of opinions may be mentioned those according to which "civilization" designates, inexclusively, the general situation in any country which has graduated through a certain phase of development in its intellectual and material life,—the requisite development in question being fixed as the invention of the use of iron, or the discovery of the art of writing, or any other analogous event prior to which man would be described as without culture, as "barbarous" or "savage." Dismissing, however, the doubts and uncertainties raised by this artificial limit, all that need be emphasized is the general standpoint shared by all the opinions in this category, and in virtue of which such expressions are used as "the civilization of Egypt" or "the civilization of Greece," terms embracing in totality the life of each, inclusive of all phases, good or bad, concomitant or not with true "civilization" in the modern acceptance of the word. Thus the historian who with this criterion and terminology describes the civilization of Greece will not exclude as a phase and feature of it either the slave system or the Greek religion, though the one appear to him unjust and the other false.

Diametrically opposed to this interpretation of the term is the category of opinions which, starting from a given dogmatic conception of civilization, partly ethical and in part material, excludes from the scope of the word anything which

[1] It is unnecessary to formulate here a list of these definitions; any one can find them out from the well known writers on the subject,—to quote, for example, several tendencies: Guizot, Burke, Gumplowicz, Henry George, Kidd, Metchnikoff, Tolstoy, etc.

is not adjustable to this conception; so that out of what is called the civilization of a given people, or of man in general, would be abstracted as uncivilized and barbarous many phases—not invariably the same—which according to the other terminology would be left included. In this group may be included all those authors who hold to be essential, before a people or a person may be called civilized, either a certain development in regard to material conditions or a certain standard of attainment respecting moral relationship and conduct. It is clear, of course, that such a category of opinions becomes divided into an infinity of sub-groups, according as the writer judges that it is impossible to regard as compatible with the ideal of civilization—being typical only of the barbarian or savage—the lack (according to his view) of justice and morality in such and such orders of life, or the need of a given religious faith, or the absence of such and such ideals, or of certain conditions of culture, comfort, hygiene, etc. And this diversity of opinion becomes still further complicated when, as often happens, it is not merely that human manifestations are split up into two categories, but further than this, that one or more of them, in a certain grade of development, are fixed upon and requisitioned as an indispensable necessity without which no historical epoch or community can be said to have been civilized,—the claim being that without this given factor all other phases of life, material and spiritual, advanced as their development may be, are at a discount and insufficient in themselves to warrant for those who represent them the description of "civilized." Most of the interpretations in question refer to cardinal necessities in the moral, juridical or intellectual order; there being others, however, for whom the favored sphere is the material, more or less associated with a certain social and juridical organization.

Now, in the truly scientific mind all these distinct standpoints and suggestions do not at all awaken the alarm usually produced in those who, for lack of a personal opinion, depend upon the opinions of others, fluctuating and distracted amid the variety afforded them. The scientific mind, on the contrary, accepts as its definition nothing other than what is naturally suggested by a clear grasp of fact—to wit, that civilization is a status of human life constituted of several and fundamental and integral elements (embracing alike intellectual, moral, artistic, anthropological and social development, with the development of mind and character), all being necessary in that they respond to conditions and exigencies of human life that are also fundamental; further, that their respective development is not parallel and uniform, either in the general history of humanity or in the individual history of each realm, and that what is properly speaking the conception of civilization is a standard and ideal of life according to which we appreciate every historical actuality and gauge the status and situation of every phase and order of the life of nations. Our basis is the conception of a perfected existence, and it is in relation to this conception that we signalize grades of perfection and development, of approximation to the ideal.

Now, for ourselves, for the nations of America and their offspring in America this ideal is the ideal of European civilization in what it possesses that is common and inherent among all the nations which have collaborated in it through the ages. But now, above and beyond this there exist other communities which it cannot be denied have attained a high level of "progress" in other directions, and which cannot therefore be ostracized from civilization—communities whose standard and ideal differ consciously from ours in many fundamental aspects. Such is the case with China, for

example; and it is the truth, however much one hesitates to recognize it through attachment to our own special manner of regarding things, that in this fact is demonstrated beyond doubt the existence of different historical directions of civilization, or at least of two—namely, European and Asiatic. The greater or lesser probability of the former ultimately absorbing the latter, apart from the fact that it is a moot question whether the probability embraces an absolute absorption or only a partial substitution in given phases of activity, does not invalidate the fact that there have existed, and exist to-day, these two fundamentally distinct directions, and ought to create in us a certain caution in venturing on dogmatic assertions.

Returning again, then, to the question of the integral elements of which civilization is constituted, there are two things we must observe: first, that these elements respond to different manifestations or types of human development; and, secondly, that our researches are not limited to merely ascertaining the existence of such elements, or even their degree of development, but their adaptability, their qualifications for fulfilling the ideal of life aspired to. And, moreover, it should be noted that the importance of the elements in question as inherent properties of the human species is not enough to satisfy us, but that we insist emphatically on the question of their *relative* importance, their situation in a hierarchy and order of necessity, either in recognition of a factor which is higher than the will of man, or as an operation preparatory to uniting the best efforts of men in developing and perfecting in a self-conscious plan that element which, of all human manifestations, is most highly prized and estimated, and regarded perhaps as the basis of the rest. And it is of course undeniable that, from the distinct standpoints adopted in this problem result distinct social, political

and educational criteria and distinct views of history, past and present, and of the achievements of man in general or given countries in particular.

But observe, now, the difference between the problems and divergences here raised and those resulting from the admission or non-admission of such and such phenomena into the sphere of civilization. In the present case there is nothing of that contradiction and confusion resulting from mutually destructive exigencies of inclusion and exclusion, for in this case we admit the reality and necessity of all. What is proposed is to determine a scale of importance or a hierarchy between the factors of civilization. All we have to do is to compare, for example, the position of Ruskin, who maintained that Art is the most important element in life, with that of Marx, or the position of those who regard intellectual development as the main factor on which everything depends, with that of the advocates of the moral or religious factor in place of the intellectual.

This question of hierarchy is the cardinal question, indeed, which the problem of civilization raises, because it affords at the same time the key for our judgments of both the present and the past and the solution of the question as to what sort of rational influence and guidance is to be exerted by the will and intelligence of man in the directing of his life along a certain route, or the adoption of a given organization and régime. It will be said, without doubt, that this is not, properly speaking, an historical question, but rather a political one (in that it embraces the organization of life), or pedagogical, in the higher and wider acceptance of the word.[1] There

[1] Some schools, however, have considered it as, actually and strictly speaking, historical: for example, Marx, who does not affirm his theory of the predominance of the economic factor as a rational necessity which *ought* to be granted, but as a fact and a reality which has always existed, and which from this historical basis derives its real essentiality.

is no denying, however, that any one who approaches this question is obliged to seek in history many of his data for the solution of it, and that its solution is bound inevitably to react on his outlook upon history. At least no one can be indifferent to this question. The question as to whether it is the egoistical and utilitarian principle, in the material acceptance of these terms, which is to triumph in the world, or the ethical and altruistic; the question as to whether our present life embodies in itself its own aim and culmination, or has to be directed toward a posterior and ultra-terrestrial goal, in relation to which it is merely a transitory and preparatory phase to be regarded as such and nothing else; the question as to whether the world of the future has or ought to be "Greek" in character or "Carthaginian," interpreting these names, for the moment, in the idealistic signification which a tradition, whose reliability it would be out of place to discuss here, has given them across the centuries, is one that ought to be the concern, and in fact is the concern, of everybody, and in the solution of which that experience which is offered by history in the shape of the positive issues which characterize two main directions of civilization is a guide of considerable importance. For this reason, in the theoretical argument conducted between educationalists, politicians, theologians, and philosophers, full and comprehensive knowledge of the civilizations of the various nations as inspired by one or other of the ideals in advocacy, or by a proportionate conjunction of them, is a basis that is indispensable, bringing us away from problems which are in the melting-pot of other sciences to the strict field of history—itself a fresh comprobation, let it be noted, of the organic relationship, close interdependence and essential intrinsic unity in which all departments of human thought are included. A true understanding of man's labor in the world, and of the prac-

tical issues and effects of each of the great human divisions of civilization, without the admixture of prejudice and fiction, without the substitution for corroborated truth of unscientific suppositions, is thus an exigency which is more than merely historical, which transcends the proper limits of history and brings us into the arena of man's highest preoccupations in relation to the future; while it is clear, of course, that if there is much in history which, after an impartial segregation of what is definite and trustworthy, is left over as uncertain, that section of historical knowledge which is a secure and arguable basis can only possess a relative value and a limited application,—this, indeed, being the first point which it is both the right and the duty of the historian to confess and discuss before such as apply to him, in the interests of other sciences, for the material and data which are his monopoly, and in regard to which he alone is qualified to speak. . . . Hence, then, the paramount importance of a comprehensive and scientific history of civilization; for this reason, also, all the investigations of historians, properly described, and of sociologists, economists, pedagogues, psychologists, etc., respecting the factors which, as such, have really actuated and are actuating the life of man,—respecting their manner of operation, their mutual action and reaction, their hierarchy and, finally, their issues and effects,—are indispensable in the attainment of a real and thorough understanding of human history, and demand, therefore, the most rigorous exactitude as regards scientific proof. So long as they lack the security of corroborated truth, there can of course be no deductions regarding them—a fact which should be remembered by such as are impatient for categorical conclusions.

The other question which stands out with the above as of cardinal importance is that of the persistence and continu-

ance of civilization. We know, as a fruit of modern criticism and research, that the theory of continuous progress is, at any rate, a false one; that history offers repeated instances of reaction and decadence now on the part of one particular community, now in a whole group of such communities (those, even, of an entire continent). We know also that there have been highly advanced civilizations that have disappeared from the world without any transmission or absorption into other communities distinct from those that embodied them, civilizations whose thread has broken and whose labor has remained for centuries and centuries buried and abortive; and in the contemplation of these facts it is only natural that uneasiness should gain possession of us with respect to the future. Is it not possible that the future may witness regressions such as that of the Middle Ages—a reaction which embraced all the most civilized races of the world? Is there not a possibility that the entire labor that man, up to the present, has accomplished, may one day be annihilated, swept from the face of the earth and lost as a heritage for future ages? Ought we not take into account the intervention of geological upheavals such as those which fiction-writers have depicted in stories—without, of course, any scientific value? Moreover, in the background (it is useless to deny it) there is always this same awful specter, the possible annihilation of the whole human race itself, some sudden uprooting of its entire records, a possibility which chills the spirit of those who contemplate it, and engenders a skeptical feeling of futility—the futility of a struggle upward toward a better life which is ultimately to better no one, which is doomed to be abortive. It is enough, indeed, to recall the possibility that, apart altogether from climatic aberrations or the destruction of large parts of the earth's crust, this discontinuance may, none the less, occur,

as has happened in times past, without the factor of geographical changes.

Against these potentialities of the future we cannot thoroughly tranquilize ourselves or remove misapprehensions without a thorough investigation of the following historical questions: the conditions which are normally favorable to the diffusion and transmission of the distinct civilizations represented in the different communities, and the difference or resemblance to be noted between present conditions and past; the object being to ascertain whether, in the existing situation, there are not certain new conditions which render less possible, and perhaps impossible, a repetition of those reactions and recessions in the progress of great masses of humanity (masses embracing, apparently, the most important branches of the race) which have imperiled or delayed during immense intervals the general labor of mankind, and entailed endless recommencement and repetition. Afterward as a practical issue of this, we ought to determine the actual safeguards necessary in order that this function of transmission may be better guaranteed for future generations.

In regard to the first question, modern science already possesses certain positive knowledge resulting from the concrete investigation of given historical instances of the transmission process, as also from the criticism and speculation which has been accorded the phenomenon in connection with the comparative method of investigation, especially in regard to the legitimacy of deducing and presupposing the fact of a transmission (without previous knowledge or detailed investigation of the case) from the simple fact of a coincidence of institutions.[1] It should not be forgotten, however, that

[1] The same may be said of the Theory of Imitation of Tarde, which can only be applied with great caution. *Imitation is a phenomenon of diffusion.*

for historians there are still many doubts and uncertainties in the verification of this phenomenon with relation to events that are of great historical importance, the study of which cannot yet be considered as exhausted or reduced to definite conclusions. A definite though general theory, of wide application apart from the specific differences of each particular case, cannot strictly be established except after a series of monographic studies of other data in connection with this process, extending over as wide a field as possible and necessitating what has still to be a long and complicated labor before generalizations will be permissible.

While fully appreciating the great importance and interest of these investigations, we must observe, however, that for our own particular purpose—in connection, that is, with the problem we are here considering—they lose much of that interest when we come to the second of our questions—namely, the question of the difference or resemblance between past conditions and present in regard to the facility with which the issues and achievements of civilization may be transmitted and secured as permanent; for, if we could be certain that existing conditions, over and above being more favorable to the process of transmission, actually guarantee and safeguard for humanity in general all the labors realized in its service, then our conclusions in regard to the first question are, for all practical purposes, at a discount. In effect, without further parley, it is actually the case that, from what we know of the past and from our observations of the present, there are enough grounds for affirming as a definite conclusion that existing conditions are, indeed, far more propitious than at any other period of history; on this there is no longer any serious doubt. And with the reassurance the fact brings us, we may satisfy our qualms, confident that what we are accomplishing to-day will not be wasted in

the future, and that the fruit of present labors will be reaped by our successors. We are aware, also, that this security is due chiefly to the development of material civilization, which, indeed, possesses here one of its foremost vindications and highest claims to attention and furtherance; for, in augmenting and facilitating the means of communication between communities, it is not only approximating but at the same time solidifying them in a bond of mutual interests forever widening and forever becoming more closely associated and interlaced, rendering thus more feasible and rapid the diffusion of that culture which, from being self-centered and destructible as in the old days, is evolving now into the universal and the permanent. The fact of life's present uniformity, of the expansion and domination of a common type, and even of the same forms and details in many branches of activity, is sufficient evidence for this contention; and although it may be resented and deplored from another—an idealistic—standpoint, in so far as it threatens us with a monotonous sameness throughout life, destructive of the personal character of each given people, it stands out among the facts of history as one of the most important and significant circumstances in the question at issue. Concomitantly with this immense attainment, modern times have witnessed also a wide and fruitful labor of assimilation which applies both to the modern world and the ancient. For, in regard to the former, the modern aspect, material civilization, while it spreads and implants a fixed form of life and a series of common industrial appliances disseminated from their point of origin over the face of the globe, at the same time, and as an inevitable issue of this centrifugal movement, gathers in and abstracts from each individual person or community of persons the fruits of the original genius of the individual, further developing thereby the whole—that is to say, making

it forever richer and more complex, and facilitating the reciprocal action and reaction of the one upon the other. In regard to the former aspect, the amazing renovations in historical knowledge and the resurrection of so many peoples buried for centuries from human ken, and for this reason useless in the advancement of man's labor, have enriched quite suddenly, or in a space of time so short that it is almost negligible as such, the heritage of modern civilization, and enabled us to reap the richest fruits of defunct civilizations of the past, which we have incorporated in our own—to the extent, that is, of all that is of use to us, whether in the shape of some practical element of utilitarian service or some educational contribution toward our imagination, taste or ideality. We have only to compare what at the end of the eighteenth century was known of Greece, Egypt, the oriental civilizations, and even of Rome itself, as regards the art, industry, literature, science and jurisprudence of these countries, with the information now at our disposal, to appreciate the immense advantage which in many matters we possess over our predecessors. The classical restoration movement initiated in the Renaissance has, in these days, developed and augmented in a manner unhoped for and amazing; and if to this we add the deeper and more extensive penetration we have realized into so many other epochs of the past, and from which so much, until now buried and forgotten, has returned to enrich our civilization,—medieval literature, primitive art, the pre-Renaissance philosophies, etc.,—we realize in how great a measure, in the past unparalleled, modern civilization embodies the civilization of all history and is truly universal, truly the civilization of man. And this stupendous achievement, let it be added, is due to the historians, the disciples of a school of study whose practical value is so often superciliously denied.

But now, when all this is said, with all the hope and reassurance for the future which it brings, we cannot deny, after an analysis of our feelings on the subject, that we are not equally at ease on all the issues it embraces. Although it is true there is no longer any doubt as to the persistence of everything which signifies material progress and of that common heritage, scientific and literary, which now seems definitely embodied in our life, we are not equally certain as to the continuance of other elements of our civilization more closely dependent on changes of thought and conduct. The material progress we have realized is so intimately associated with primordial necessities of human life and with appetites—or, if you prefer, aspirations—inseparable from human nature, such as the competitive stimulus and the commercial factor, the craving for economic profit and material comfort, that renunciation of these things seems to us impossible outside the hypothesis of some general mental aberration in mankind. Nor is the retainment of all the learning and culture elaborated through the centuries, and of the beauties of literature and art, a cause for anxiety in so far as such a process of retainment is purely passive in character, while the inspiration of these beauties and that culture is practically inextinguishable in the human species. But in everything that is influenced by opinion such as is not secured on the bedrock of the experimental sciences, or in which other factors are at work in the form of speculative conceptions whose foundation is rational and not empirical, or of feelings of another order from the appetites and aspirations previously referred to, a good deal of misgiving, despite the optimistic outbursts persistently indulged in, has to be confessed after considering matters impartially and scientifically. Who, for example, has not felt the possibility that the unmistakable advances we have realized as regards social

and political organization, in the general province of law and the moral conception of life, may not, after all, be doomed to immolation before some sudden metamorphosis of human thought and opinion, as illogical, according to our present judgment, as you like, but not without precedent in the history of many countries,—embracing, moreover, widely extended areas? What meditative mind has not experienced, at one time or another, uneasiness over the possibility of the general orientation of modern thought being finally supplanted by another, to the entire subversion of our basic conception of the world; or of our literature and art sinking into a decadence in which they will be rendered extravagant and impotent?

With these considerations we are brought to another question that is associated with this theory of civilization—namely, that as to whether all the orders of our life are following a necessarily ascendent path—that is to say, a course of indefinite improvement, considering their history as a whole and discarding mere temporary setbacks; or whether there are not certain orders which are exceptions to this rule, different and distinct in character from those subject to a continuous progress; whether, moreover, there are not others whose point of culmination (in man) has now already been attained and will not be exceeded, perhaps not even equaled, in the future. And, as a natural consequence of the comparisons and contrasts necessitated by this study, there follows yet another question which is repeatedly occupying thinkers—namely, the question of a proportion or relative development between the distinct reaches of human activity, or, broadly speaking, between these two (to be taken as embodying the two main divisions of the facts of civilization): the moral order and the material.

Coming to a closer consideration of the first of the two

questions raised, we shall see that while historical investigation has enabled us to determine the existence, across the ages, of a fundamental current which, in spite of temporary deflections, has always, in the long run, triumphed, mounting now higher and higher in the conquest of Nature and the applications to human necessities of her elements and forces, expanding in the sphere of social organization and in the direction of popular liberties, as also in artistic manifestation of a certain order,—yet, on the other hand, we cannot say the same of all the provinces of, for example, art, nor of all the orders of scientific research, and still less so of the problem of moral conduct, especially as regards certain of its most important branches. How many times has it been asseverated that Greek art, in certain branches, is insuperable, and that none of man's subsequent creations are to be compared with it,—not excepting those of this modern era, despite the higher reaches of modern culture and its boundless sources of nutrition from the past? Who is not aware that, in spite of the great progress of philosophy since the Renaissance, its present situation is still fundamentally inseparable from the doctrines of the Greek philosophers, whose thought we have not, in many things, so much as widened? How often have we not been told that music in the great German classics was carried to its apex, both technical and ideal? Who can deny that modern literature is far from monopolizing all the greatest productions of literary art, and that many of the great masterpieces in this line have been the work of the ancients—a fact implying that the line of development which this departure is following is not subject to the same law which is guiding other orders and unmistakably urging them still forward? And finally, who can escape the bitter confession that moral development is still exiguous, that customs are not improving all around, and

that the higher ethical doctrines remain untranslated into action in the practical life of the majority?

Let it be observed, however, at the outset, that there is a strong possibility of error in these affirmations and comparisons, owing to the influence of a traditional tendency, still prevalent, in which the "classical" is seen as a type and standard handed down to us from the past as something perfect and insuperable, by which we have unduly limited the future, with all its hidden possibilities—possibilities in the way of new departures in the sphere of art, thought, originality and culture. In face of this doubt and uncertainty arising from indefinite and what are for us mysterious possibilities of new departures and new doctrines, a past status of perfection loses the importance it would otherwise possess could it be definitely stated that never in the future will this standard either be superseded or equaled. It would be sufficient, as regards art and literature, that the future should produce things of equal supernal beauty to the great masterpieces of the past, although the ideal which inspires them and the means and medium of their expression may be different.

Furthermore, it should be remembered that the only conclusion of any practical value which is to be drawn from the fact—supposing it to be a fact—that in certain human departments of thought the goal of achievement has been arrived at in past ages—*i.e.*, Greek sculpture—would be that certain branches of progress are more easy of development than others, and have thus been exploited and exhausted, while others are still in the process of development. The immediate consequence of this conclusion in its influence on our conduct, as one of the educative results of knowledge, would be that we should dedicate the greater part of our energies henceforward to developing all that is relatively backward,

withdrawing such energies to a great extent from the fully exploited branches whose pursuit, it would seem, can only be attended now with lesser results. Perhaps, indeed, in certain modern propensities, in certain orientations of the main body of humanity to-day, which seems to be cultivating by choice precisely those branches which are only imperfectly developed, there is a vague but effective consciousness of this necessity.

What is of real and actual gravity, however, is the fact of the enormous disproportion between the highest results which have been achieved in the ethical department and those of the other orders. This is an historical fact which is evident, even without any special study of the matter, to anybody, and on the strength of which we may divide the manifestations of human life into two groups: one in which are embodied all those branches which, it may be said, have on the whole expanded and developed and are continuing to develop in a conspicuous manner, or else have already in the past attained their apex of perfection, though to-day in a state of collapse and effeteness,—manifestations belonging to the artistic and intellectual sphere, or representing the material civilization which has resulted from man's dominion over nature and from the applications of science, and also to certain aspects of social organization; while on the other hand is the group which embraces the element of moral conduct and certain other directions of social and juridical organization, phenomena which either have not developed in any perceptible degree or are obviously behindhand compared to the phenomena included in the first group.

It would be superfluous to reopen here the discussion which years ago, when the literature of the Philosophy of History was flourishing (that literature which dazzled and misled so many people, while it offered little that was of real

scientific value), raised such impassioned argument owing, perhaps, to the radical form in which it was planted and the rash manner, disregardful of requisite historical data, in which it was approached,—the discussion of the question: Is there or is there not such a thing as moral progress? Such absolute questions it will be a matter of common agreement to discard as fruitless because no one doubts the fact to-day that, in certain aspects of his moral conduct, social and individual man has actually advanced, and that the practical ideal which is being realized in the higher circle of society is superior to that which prevailed in such circles some centuries ago. And simultaneously, in the juridical sphere, in the strict meaning of the term, accepting the common distinction between morality and law,—a distinction which is not necessarily exact,—it is equally beyond doubt that justice is, on the whole, becoming more and more actual in many of the human relations it affects.

But by the side of this twofold conviction which we possess it is equally unmistakable that the moral and juridical order still, in many of its phases and even in the most advanced communities, embraces what is immoral and unjust, and that the majority of individuals are likewise immoral and unjust in many features of their lives. The discouraging impression which these facts produce in us is not so much suggested by the evils they infer as by their exposure of the inefficacy of doctrines and ideals proclaimed and effusively embraced by millions of human beings many centuries ago. It is comprehensible that there are certain sciences which have not at all times realized the perfection and development they have now attained, because the advance of these sciences has followed from the grasp of certain truths which have only latterly been realized; but the ethical and juridical ideal, in its application to social and individual life, has been realized in

many of its fundamental aspects since immemorial time,—yet, nevertheless, it has produced only the most exiguous effects relatively to the situation which preceded its adoption or to its exigencies as an ideal. This inefficacy or extremely limited efficacy of the moral ideal is what disheartens the sincere observer and at times causes him to despair of the province of morality, even theoretically admitting the development attained in the other provinces of life, or at least to demand why it is that this element is to be found in what is perhaps an immense inferiority to others, and is, at all events, held in less importance among the problems of life.

This situation is explained, according to modern theories, on the hypothesis that moral advancement is not solely dependent on the advancement of ethical ideas, but also on other factors belonging to other orders—factors which in most cases have made their appearance long after the actual ethical ideal. A good illustration of this doctrine is Buckle's instance, in connection with war, of the decline of the warlike spirit in humanity. For Buckle, as is known, the three great causes of this change have been: the invention of gunpowder, Adam Smith's book on the "Wealth of Nations," and the use of steam in land and maritime communication; that is to say, three factors wholly distinct in origin and character from the moral sentiments which, at first sight, would have seemed to be the principal causes of this momentous change. In like manner, other authors, of philosophic affiliations very different from those of Buckle, have shown that in the abolition of slavery in Europe and in the betterment of the juridical situation of the land-laboring classes, moral motives represented only an exiguous influence, while economic motives, on the contrary, were paramount.[1] These

[1] For all that is to be learned from Spain in this matter, reference should be had to the standard work of Eduardo de Hinojosa: "The Feudal System and the Agrarian Question in Cataluña," Madrid, 1905.

and many other historical examples appear to establish the theory of the school in question, according to which moral progress is made dependent on scientific development, or on the changes at work in other very distinct orders of life,—a theory according to which the relatively backward situation of the moral order is explained by this observation of two facts—the fact, primarily, of this same dependence of position and the fact of the personal and intransferable quality of moral actions. "Whereas intellectual acquisitions," says an exponent of the theory, "are transmitted scrupulously from one generation to another and the attainments of the moral faculties are not transmissible, in that every one must practise goodness for its own sake, by the nature of it goodness is essentially personal and private, and even the good which is realized by the purest and most diligent philanthropy is of limited duration and can only benefit a comparatively small number of people. The actions of the bad produce a transient evil; those of the good, a good which is equally unenduring: it is only the discoveries of the great thinkers which subsist eternally, survive the ruin of empires and the fluctuation of beliefs, follow and are added to each other in succession, and stand alone immutable amidst the ephemeral and fugitive, serving as landmarks in the progress of humanity."

There is of course obvious exaggeration in some of the above affirmations, for neither is the moral element so changeable as is suggested,—a certain sediment always having persisted and affirmed itself through history,—nor can it be said that nothing of what is attained in this order can be added to previous attainments in the way that intellectual advancements are recorded and accumulated; nor even is there entire justification for the theory that the effect of a moral effort can only be passing in duration, for such an

effort, when it becomes crystallized in a social labor or social institution or in a reform of customs, may be prolonged through great periods of time and become incorporated in the general conduct of a people almost finally and unalterably, descending and extending to an immense number of human beings. These discrepancies, however, do not invalidate the general truth of the theory as regards the intervention of non-moral factors—factors, that is, of a different physical and spiritual order—in the achievement of advances in the actual domain of morality, nor the force of the theory as an explanation of this same disproportion in development which we are concerned with—this albeit that it is not a matter of such certainty that the inevitable action of the intellectual over the moral implies an absolute subordination of the latter to the former, in so far as the influence exerted by the human intelligence over human conduct does not invariably signify the actual suggestion of new lines of conduct, but represents in many cases merely the thought and reflection granted certain principles of life defended by the moralists, —reflections that have resulted in a conviction of the essential necessity of the principles in question;—intellectual progress, in the strict meaning of the term, thus, apart from all it represents in its own sphere, being converted through this relationship into a means for serving and furthering the end of most importance—the object, that is, of moral progress. The fallacy in the argument that because intellectual advancement, as is contended in this theory and in fact admitted by us, is the impulse of civilization, it has for this reason to be considered the measure and criterion of it, is evident when we consider that progress does not consist merely in the declaration of principles or in the act of mentally appreciating them, but in their practice and realization —assuming, that is, that the first and basic necessity in life is

goodness; the contradiction, moreover, between belief and conduct, between thought and action, is sufficiently glaring in our lives to save us from the error of deducing the purity of the latter as an inevitable issue of the truth and beauty of the former.

But now, so far as our main question is concerned,—the actual question under discussion,—the fact remains, whether we hold this theory to be valid or regard the two spheres in question—the scientific and the moral—as independent, or at least independent in many of their aspects, that we are still left with the same doubt as we started with, though embodied in two forms. On the first hypothesis—that of our accepting the theory—it is necessary to ask: Up to what limit will scientific development be able to influence the moral conduct for whose growth it is responsible? In the second case we are faced always with this question: Is the present disproportion between the development and evolution of both spheres to be permanent; will it, in time, become diminished, or is it to be augmented still further in the future? And in either case, what is the impression, optimistic or pessimistic, that we are left with after the study of all, in this connection, that history up to the present has afforded us?

But now again, it is not impossible—in fact, it is very probable—that the question is still imperfectly stated owing to the need of a further discrimination. In short, are we so very certain that all the actions usually comprehended in the sphere of moral conduct belong to the same order and destiny? Does not historical observation, on the contrary, suggest that there are two distinct classes of manifestations in this order whose difference may be said to have found expression in the distinct directions they have taken across history? This very obvious distinction, already noted in a preceding argument, that exists between certain features, on

the one hand, of social morality, embracing determined aspects of human relationship—orders that have developed in moral status, and become purified, possessing what is perhaps an inexhaustible capacity for continued purification and development—moral attainments such as honor, tolerance, veracity, impartiality, etc.,—between these and other features of social and individual morality, as far as the distinction is possible, which are plainly making no headway and in which the element of evil is as prevalent to-day as centuries ago, is surely a powerful argument in favor of the theory that there is one branch of our moral life which is capable of development and another in which all progress seems impossible, or at least has seemed so up to the present. That this is the case is, in my opinion, beyond doubt: I believe that the experience of history demonstrates with the utmost clarity that there are moral inclinations in our nature which can actually be checked—which have, indeed, been suppressed among certain communities, with a resulting transformation in popular customs; while, on the other hand, there are others, always precisely the same, which, subsisting as they do in passions apparently ineradicable, dominated and subdued by only a limited number of people, not in each case the same elements, have not been subject to this rectification and continue as sources of evil. Such is the case with envy, anger, cupidity, ambition and the craving for luxury, and a whole series of other tendencies elemental in our nature whose products in the form of misery and privation are utterly horrifying as represented to us by modern sociologists, psychologists and criminologists, such abominations in our days scarcely being considered possible.

These, then, are the actual facts of the case, the results of historical investigation, and beyond the field of these facts, on any scientific basis, we cannot venture; for every predic-

tion is merely a hypothesis, a problematical supposition with relation to an uncertain future. Human aspiration, however, does not resignedly surrender to a simple recognition of the facts as they now are and have been in the past—in a recognition, that is to say, of history. Hope ventures into the belief that it will also be possible to rectify, finally, that which has seemed incorrigible, to subdue those forces which up to the present have been irrepressible, and so to subdue them that the change shall constitute a social triumph, incorporated as a definite conquest in the civilizations, first of the most advanced communities, and finally of all. Such a labor, in fact, if we come to think of it, embodies the cardinal problem of education, and it is on the appreciation of this problem in the alternative attitude of optimism or pessimism that depends an important difference in the prevailing scholastic system. "Education will do everything!" or, "Education is subject to impassable limits in human nature generally and in each individual case in particular!" Such are the two conflicting statements. The second bases itself on the concrete data of experience, the first on a generous confidence in the perfectibility of human nature and the efficacy of method; and so inspiring is the conception it awakens in us of the future that it has won the powerful support of great men like Goethe and Guyau. Although the main course of pedagogy is to-day following another direction, refusing to admit the omnipotence of education, it is certain, for the moment, that any absolute and categorical answer to the question will be problematical. This question the advances of psychology, social and individual, may enable to be answered in the future. At present the most we can do is to formulate the problem.

But this same uncertainty and doubt which arise, on the one hand, from the weakness of our hypothesis respecting

the future, and, on the other, from the results of our study of the past, serves at any rate to bring us to grips with the urgent and dominating question: What is it that is of most importance in life? If mankind is not improving morally, what value is there in the other branches of his progress? For what do they serve but as a merely superficial satisfaction and a delusive mask to the virtual wretchedness in which the immense majority of individuals live?

Let us now fearlessly approach this question, which, although, like others we have been dealing with, is apparently disassociated from an investigation properly speaking historical, is as a matter of fact essentially allied to such a study. The question is inevitably associated with the ideal of life which ranks the ethical factor (and quite rightly so, no doubt) at the head of all, maintaining that, as compared with this, material or purely intellectual advantages are of little value; while, for another thing, it presupposes that all the elements, both material and spiritual, of human life have necessarily to be equally perfectible. As a result of this double supposition every deficiency in the moral order fosters, it is clear, discouragement, pessimism or censure, with all the perplexities that historical data awaken with regard to the disproportion between the march of the two orders. But the question to be considered is whether, while admitting the first supposition (for me it is beyond doubt, and in fact I believe most firmly that the main value and significance of our advances in the intellectual sphere and the material consists in such assistance as they provide for the juridical and moral element in its task of facilitating a real understanding of the world and the subdual of natural impulse), there is not a great error in the second. Would it not appear certain that, distinguishing as we do between two spheres or groups of actions and relationships in that province of civilization

whose backwardness we are discussing, we should confine ourselves, without embarking on the impossible, to the perfecting of those elements which are perfectible, according to our evidence from history, while on the other hand recognizing, and resigning ourselves to the admission, that there are other elements which lack this capacity of growth, and in respect of which the only feasible course, with human nature as it is, is to limit their scope for evil, redeeming the maximum number of individual cases, and, in short, diminishing the deplorable influence they exercise (it being impossible to suppress them), as is being done to-day with many of them by means of legislation, police, prisons and reformatories such as are worth the name, and even medical treatment in its particular province?

If we were to take this course and bow to the inevitable, we should be relieved once and for all of the warring preoccupation over an impossible ideal, over the incompatibility between a belief in this ideal and our utter failure to accomplish it; and this relief, freeing us from the despair which is born of failure, would enable us to direct the best of our energies toward what is feasible, discarding from the field of historical investigation problems which have ceased to be problems. And then, indeed, our whole theory of civilization, springing from a recognition of the facts of history and the undoubted progress realized in the majority of our activities, as also of the fundamental orientation which the whole of human history seems to contain below the surface of its racial differences,—an orientation which is not prejudicial to the original genius, necessary as long as harmless, of each social entity and group,—would have as a practical result for the present and the future the ever intenser application of those means and processes by which, up to the present, progress has been realized, especially with the object of

accelerating the march of those phases of progress which are behindhand, and of maintaining the equilibrium in which the development of one order will not be sacrificed to that of another, either in dragging humanity into a life of egoism for a more or less considerable number of people merely voluptuous and sybaritical, or in depreciating intellectual and material evolution in favor of an esthetic ideal and moral standard, to which mankind is to be converted, incompatible for society with all the other achievements it has realized.

Well, now, if we reflect on the aspirations of contemporary civilization as they are manifested and expressed, we shall see, as was mentioned before, that all these manifestations affirm the resolve to secure and conserve the material civilization now flourishing, to augment and at the same time disseminate it, embracing the widest number of people and thus converting it from the monopoly of the few into the heritage of the majority, and, if possible, of every one; also, that this same centrifugal tendency is to be observed in the sphere of intellectual culture, forever seeking to penetrate more widely the masses at the same time that it is perfecting the conditions of the higher investigation which is reserved for the chosen few, but open to humanity in general in the glory of its issues and conclusions. And concomitantly we shall observe that, alike in the flower of humanity and in the surging masses, there is a cry and clamor for the ethical basis to life, a demand for the reign of justice in the sphere of jurisprudence, of the good in the sphere of morality, these being the things which are our only guarantee against the tragedy of a life of hatred, tears and curses,—in search of these things, however, always in the consciousness, given an impartial recognition of experience, that there is a surplus of evil still undominated, which is probably indomitable, and which embodies the unavoidable lot of human imperfections, human limitations, which are defiant of human will.

III

THE METHODS OF EXTENDING CIVILIZATION AMONG THE NATIONS

WE were saying in the preceding lecture that the general problem of human history—or, in other words, of civilization—embraces two classes of questions. The first of these we have endeavored to answer in the before-mentioned lecture. The second, although it has been the subject of many previous allusions, we shall now answer more directly, in order to arrive at the treatment of the concrete question in reference to Spain.

We must bear in mind that our object is to ascertain by what methods civilization is evolved, and what is, in consequence, the best course to adopt in order to strengthen and advance it.

Passing over the beginnings of history, when each family or human group (if we admit the polygenetic theory) or the family nucleus (if we accept the monogenetic theory) either must have been self-taught and have had to select for itself the most important lessons which nature offered, or must have arrived at the principles involved through the inventive power of human intelligence, there is no doubt that the instances of autodidacticism, collective and individual, are the exception, and that when they do appear they have but a limited field of development and leave no lasting impression if they remain in the isolation in which they were conceived.

The general law of civilization, as in education (and, strictly speaking, are they not the same?), is reciprocal influence and mutual teaching. Those who teach others are at

the same time taught. There is a continual ebb and flow of suggestions, corrections, imitations and reflected experiences, by which each individual profits more or less according to his power of assimilation and reaction. This law fulfils itself in each group, acting between individual and individual, between individual and group, and *vice versa*. The same process takes place between group and group, although it may be possible that during the centuries one group, or a combination of groups, has become isolated and has continued to develop an acquired impulse by virtue of the continuous growth of human powers and the more than geometrical progression of their advance. The latter seems to have been the case in primitive America.

This law takes effect without the knowledge of those it influences and even against their will, as happens, for instance, between hostile peoples separated by mutual hatred and respective interests,[1] or as occurs with those peoples who attempt to isolate themselves from their neighbors (as though this could be accomplished even should all the laws of the world seem not only to sanction but to command it under a thousand penalties). Aside from the fact that this law invariably works itself out naturally, man applies it reflectively. He civilizes individuals through education (schools, academies, etc.). Nations he civilizes sometimes by imposing upon them a régime which influences the great majority (*e.g.*, the process of Romanization of the provinces in so far as this result was intended and sought after by the Romans themselves), sometimes through individuals, these individuals being chosen, as in the modern method of awarding scholarships for study and travel, to learn at first hand the history and customs of peoples who are considered more

[1] For example, in the case of Mussulmans and Christians in medieval Spain, who, notwithstanding their constant warfare, influenced each other to a great extent.

advanced, in order that the knowledge thus acquired may be diffused throughout the student's own country.

In this way the civilization of each group continues to progress, impelled by that which each group receives from the other groups and by that which originated within the group itself. The absence of either of these two factors would disturb the equilibrium of the civilizing process, since to influence and to teach, a people must have created something, and even that people which has created nothing equal to the productions of others, must have in its mental composition an original element on which to base and mold into characteristic form those qualities borrowed from its fellow beings. A people lacking this original element (which in its turn will convert a people into an active factor in the common work of civilization) becomes weakened and atrophied as does a disused organ.

Since civilization and education are essential factors in every case, this question immediately arises: Is it right to impose civilization by force? In education this question is presented in the discussion concerning "obligatory learning" imposed upon the child, although he may not desire it, because his resistance to it (if he does resist) is the result of his ignorance of the fundamental importance of education in his life. Had the child as clear a conception of its value as the adult man usually possesses, he himself would ask that he be educated and would demand this as a right, in the same way that he would demand the fulfilment of his right to be provided with the necessities of his material life, for which, in his earliest years, he could only ask by signs and cries (at times he even refused them), but which, nevertheless, were not denied him because of this.

Let us now consider the problem in its bearing upon the relations among peoples. Probably ever since humanity has

existed and groups of men have fought among themselves for a thousand causes more or less clear, in the discussion of the motives which led to aggression men have resorted, whenever the circumstances offered a semblance of justification, to the argument that this aggression was entered upon in the interest of culture and education. In some cases this interest manifested itself in connection with religion (*e.g.*, in recognizing as a duty the conversion of infidel nations, pagans, etc., and their introduction to the true faith); in others, the argument had to do with the general welfare of humanity, which was being jeopardized by the existence of peoples ignorant, backward, fanatic, opposed to all innovation, etc., incapable of developing with intelligent effort the resources offered by their own soil,—peoples, in short, whose continued unproductivity justified the interference of the rest of mankind; others alleged that humanity was imperiled by the existence of peoples stubbornly opposed to the recognition of those fundamental rights of man without which community life and social relations are impossible. This latter argument is of recent origin; indeed, it is the child of our own epoch, and has come to replace almost entirely the argument of religion, just as that of religion replaced to a certain extent the argument of the superiority or inferiority of peoples and individuals which was used to explain slavery in classic times, and which was even advanced by certain philosophers of the Renaissance when referring to the American aborigines.

Apparently we have before us a theory analogous to that on which obligatory education is based. Nations, like children, must be taught to realize the importance of their mission; if they fail to educate themselves voluntarily, others must intervene in their affairs in order to raise them to the level of culture they are capable of attaining. Thus, the

most civilized discharge a tutelary function, aiding and co-operating toward the common good. Of the two forces working in humanity, one to advance all civilization, the other to bring about the sovereignty and independence of individual states, the former is, in the theory, the stronger—the usefulness of the latter being destroyed when it serves, as it does here, merely to maintain a group of men outside the established order and conditions of civilized life.

If this theory were correct, we should have an example of a method of civilization distinct from the two common to humanity: viz., individual effort and the normal and pacific influence of others (if this influence is not rejected or deliberately sought after). It would be, simply, the employment of the coercive method when the voluntary method was not spontaneously followed, and all that would remain for us to discuss would be whether this method may rightfully be employed, or whether, on the contrary, there is included among the prerogatives of a people's liberty the right to remain indefinitely barbarous, uncivilized, or backward and markedly inferior to the majority who feel the impulse toward civilization,—the right, in short, to be an obstacle preventing the growth of this civilization in strength, its acquirement of new methods and its extension over the entire world.

But even if we accept the theory simply as such and without raising any difficulties, history provides us with this extremely powerful argument against it: If obligatory education presupposes a compulsion, this compulsion is not used to abuse the child, to diminish his rights, to take possession of what is his,—in other words, to do him harm,—but to portion out to him a benefit in a form equally good. The theory referred to, as has already been noted in pointing out its origin, is only applied to peoples in the form of conquest.

And, even supposing that it is *not* a disguise for the mere desire for mastery, the form through which it manifests itself usually bears in its train conditions which render the theory worthless. In fact, those who have recourse to it as an excuse to interfere in the life of a nation, to seize its territory and to direct its affairs, are not in the habit of deciding upon this course for the good of that nation (this is the *fact,* no matter what *name* may be given to the intervention), but egotistically for their own benefit (to take advantage of the natural and industrial wealth of the vanquished nation, to provide room for expansion, or through pure delight in domination, etc.); or at least these considerations take first place, while the task of education is left very much in the background, or is confined to mere contact with that in which the conqueror is superior; that is to say, the tutelary mission of coöperation and of the regeneration of the less developed neighbor is subordinated to the acquisition of those things which contribute peculiarly to the advantage of the conqueror, or at least it does not occupy the preëminent position which befits it; and instead of a work of love, of concord, of mutual effort, it becomes a work of hatred, of violence, and of plunder more or less dissimulated.

If it should be objected that in such a case the end justifies the means, since in the end the less advanced, conquered people,—the Roman provinces, for example,—assimilating the advantages of the new civilization, will rise to the level of its conqueror,—if this objection is presented, we may answer that neither is this always the case (for there are many inferior peoples who have never risen to the level of their conquerors, but have been absorbed by them and so lost their own identity), nor is violence, ordinarily carried to bloody limits, the proper road to education. This deplorable result is brought about sometimes through lack of tact on

the part of the "educator," sometimes through resistance on the part of those whom he is attempting to educate. It will suffice to recall in this connection the thousands of victims of the Roman conquest in the Iberian peninsula,—victims who cannot be forgotten even in the light of the superior culture which was finally forced upon the descendants of those sacrificed. And as it was effected then, so it has continued to be effected through all history, and so it is still effected in our own times.

The question, then, immediately arises: Is it possible to accomplish this by another method? Is it possible to bring into the field of what is considered the more advanced civilization any nation whatever, without stirring up a conflict animated by that very resistance to improvement which is the result of their ignorance, and without this conflict degenerating into bloody disputes and plunderings? Or, in other terms, is it possible to educate in the same way (that is, through the action of love and kindness) as one would a child who fails to lend himself willingly to education, a people which does not desire progress? In my opinion this question cannot be answered in the abstract. We lack sufficient historical data to give a well-founded answer, for all the material which we do possess is based on contrary proceedings: the conqueror has always commenced by troubling and molesting, and has thus given a motive for the resistance. Some exceptions which we might recall, but which came to nothing (I have in mind the attempt of the Padre Las Casas in Cumaná), have usually followed bloody conflicts, and it is impossible to say what they might have accomplished by themselves if they had been employed from the start. That very division of mankind into peoples stubborn and warlike and peoples docile and submissive in the case of intervention, which the conquerors have been accus-

tomed to make, is in itself suspicious. We cannot be certain that the first classification was not often an excuse for the violent proceedings which the invaders themselves initiated.

There is, moreover, a factor in the problem when dealing with nations which greatly complicates the question and forces it into the field of violence, although this may not be the intention of the one who intervenes. This factor is the total or partial loss of independence which the intervention of a foreign power always presupposes, and which, no matter how slight it is alleged to be, bears down upon and hampers its victims, the more severely the nearer they find themselves to that state of civilization in which liberty is fastidious and does not even recognize the ideal restrictions which separate and distinguish it from free will and the most absolute personal autocracy. In the case of the child forced to attend school there is a loss of independence as he understands it; but his protests may be overruled and his struggles are so insignificant and ephemeral that they leave no traces. The protest of a people, on the contrary, is not so easily overcome, and is strong enough to bring about the violent conflict whose suppression serves to accentuate the hatred and increase the tyranny. Since even the slightest interference, actuated by the most generous purpose, brings with it *some* limitation of a people's sovereignty,—if this limitation is felt keenly enough by the people interfered with, will all the advantages that accompany it be strong enough to smother the desire to reconquer their former complete freedom? Moreover, the self-esteem, the national pride of a people is far stronger than that of an individual; it reasons less and often fails to recognize the superiority of a neighbor; consequently, as soon as a people whose affairs are under the direction of another begins to comprehend its own powers and is admitted to the same rank of civilization as

that of the nation which is intervening with the intention of teaching, it will oppose this design with all that feeling of repulsion to which the self-respect of a nation is susceptible when it is troubled by the mere suggestion that it needs the guidance of another and is incapable of working out its own salvation.

And it is to be remarked that this fact, natural in the psychology of the group and repeated in history, has been dignified in a theory which, idealizing it, has strengthened and raised it from the rank of an almost instinctive movement of reaction to the category of a recognized necessity, some of whose principles admit of no discussion. This is the position of Fichte when he names independence as a fundamental and essential condition of all culture, since civilization truly serviceable to a people must be the outgrowth of their own effort and not something borrowed or taken over ready-made from others.[1]

Except for a very few and limited examples of missions and governors in the history of our own civilization, we lack, I repeat, such data concerning loving guardianship over a people as we possess concerning the affectionate teaching of a child; but this deficiency does not authorize the statement that, generally speaking, the humanitarian proceeding would not be possible.

That of which we may be certain is, that humanity, taken as a whole, does not know how to use it. It has seen the wisdom of dealing gently with the child, but it has not yet arrived at this method of dealing with the people of another country when that country is open to domination. This historical law, true in ancient times, true in the Middle Ages,

[1] History, however, sometimes argues with examples contrary to this statement—*e.g.*, the Romanization of a great part of Europe, which produced extremely beneficial results, notwithstanding the fact that it was accompanied by domination. The truth is that Fichte theorizes concerning peoples already civilized.

true in the epochs of great discoveries and of colonial expansion, still reigns in the world to-day. And furthermore, notwithstanding certain advances in the laws of war, usually more theoretical than practical, illusory promises in the reports of the international conventions and frequently contradicted by reality, we note a retrocession in the ideas relative to this point, or a new and unsympathetic assertion (dissembled in form and not very explicit in its outward manifestations, but very clear and definite as a rule of conduct) concerning the incorrigibility of certain human groups, of their unfitness for civilization, and of the advantage of making them disappear as one would an obstacle which stands in the way of progress. At least there is a general indifference to the fact of their disappearance, even in the case when this is brought about by violence and has exceeded the limits of a natural movement for self-defense on the part of the superior group. These sentiments, I repeat, are the dominant ones which in the end direct the decisive acts of statesmen, and those which triumph beneath racial romanticisms which, in some places, have wished to bind the present life with native atavisms open to much question when considered historically, but worthy of respect from the humanitarian point of view.

The question, then, in its practical aspect is answered day by day; and it will be some time at least before any one will be able to change its trend, however fervid and however reasonable may be the propaganda against it. Precisely here lies the problem—in the fitness of one or the other line of conduct. Which of them has reason on its side? Which should prevail in the system of relations between people and people, state and state? Do there exist, in truth, peoples incapable of advancing civilization, refractory to the demands of modern life; peoples whose mere existence in or

out of a country is at least a dead weight upon the progress of that country, if not actually an active factor of disturbance and degradation, the suppression of which is a necessity?

It must be observed that the judgment of incorrigibility or inadaptability is rendered by the very group which is promoting or predicting the annihilation of that which it considers a disturbing element. This judgment, always open to suspicion, since the giver is at one and the same time judge and party to the suit, is perhaps hasty as well, when we consider that it is applied to those who have as yet experienced no attempted education. If the condemnatory sentence should come as the consequence of a systematic series of efforts sufficiently extensive and intensive to educate the people or the race qualified as a disturbing factor, there would still be room for discussion concerning the logical exactness of the conclusion, but one could never deny the fact that this conclusion had some foundation, and that before arriving at it other methods had been tried. But, as we have previously asked, which one of those peoples who have planted colonies among inferior races can lay claim to having actually made an attempt at such an education, instead of offering a "civilization" produced through alcohol, deception, abuses, and through that contempt which bars from communion with the superior race those men considered as lower in the scale of humanity?

The above consideration, just as it stands, would be sufficient to make us suspend judgment respecting the justice of that policy of domination in the relations among peoples; but we could strengthen it still further by observing that in history this judgment of inferiority has not only been applied to barbarous and savage human groups, but also to those who enjoyed a well-developed civilization; not infrequent

are the cases in which a warlike chauvinism, the smoldering hatred of nation for nation, also applies this judgment to a nation which is almost upon the same plane of development as the one which condemns it and passes this opinion only because the latter nation does not consider the other as belonging to the same "race," or because a gulf of century-long wars separates them and provokes their ill-will, or simply because exciting contempt for any foreign accomplishment was considered a good method for assuring patriotism.

Even laying aside these cases of actual injustice, of judgment blinded by passion, and also those other cases in which the condemnatory sentence is notoriously hasty and is not based on positive facts, there will still remain a few concerning which the question reappears in all its vigor. Around it the two opposed criteria of humanity will continue to contend—the sentimental and optimistic, which abhors all violent suppressions, and the utilitarian and pessimistic, which believes that such suppression is justified in the service of civilization and on the grounds of the positive inability to advance in culture which it presupposes in certain human groups. That is to say, that even on the firm ground of sociology and law, laying aside all the selfishness, all the deceits and tricks of justice which are produced by special interests ever against our wills, and all the illogical precipitancy of judgment, this question may safely be formulated, or rather, in fact, we do formulate it to-day and answer it at each step without scruples, and hence we must consider it as not to be set aside in our minds,—the question as to whether there actually exist people who, because they are refractory under any attempt to guide and educate them, should be eliminated from modern social life, if not by a quick, violent method, then by neglect of their cultural necessities and the absorption of their revenues. This recognition of our pres-

ent attitude of mind toward a question of such importance should serve us as a touchstone for investigation and judgment of past conditions. If humanity to-day, with all its progress and culture, is still doubtful on this particular point, and, what is worse, in actual practice still continues to apply the system of domination and fails to recognize tutelary education, or else does not apply it when it should, how can we be surprised that in other centuries humanity less cultured, harsher, and more implacable toward man, less influenced by the principles of fraternity and solidarity, should usually have proceeded in the same manner and fulfilled its duty of transmitting civilization either by subordinating it to its own interests, or imposing it by force, or judging that not the conquered people were worthy of it, but rather the conqueror in the dissemination of colonies which conquest itself brings about? Undoubtedly the fundamental work for a knowledge of actual human history is a thorough investigation as to how each people, on coming into contact with an inferior race, has understood its relations with that race in the light of its duty toward civilization, and how it has effectually realized them (favoring now one system, now the other). This investigation up to the present time has been undertaken only in a fragmentary manner (that is, with reference only to certain peoples, and, strangely, to certain definite classes of culture and of social life), and often in a spirit of partiality which sought only faults, not facts. The *Kulturgeschichte,* aspiration of the theorists of the Renaissance, cultivated in the learned manner by many historians of the eighteenth century and reduced to a system by those of the nineteenth, is still in the main a collection of general laws whose ideal interrogatory lacks many of the questions which might explain its processes and give significance to the material on which it is based. One of these questions—and

one of the most important—is that which we formulated a moment ago. While this question remains unanswered with that fullness which its conception demands and with the scientific accuracy which would exclude passion and injustice, we have no right, even from the most rigorously sentimental and humanistic point of view, to judge any people upon this phase of their conduct, because we would lack the exact and complete knowledge of what they had accomplished, and, consequently, the ability justly to compare this with what the rest of mankind had achieved.

This is the case of Spain considered as a colonizing country. Since Las Casas published his "Destruccion de las Indias" (1552), Spaniards and foreigners[1] have discussed not only the problems proposed by Las Casas—as, for instance, the right of conquest in America (the justice or injustice of the war), the personal liberty of the aborigines, and especially those acts of violence, unauthorized even by war itself and which more than anything else aroused the pity and the just spirit of the famous friar,—but also our entire colonial policy and even our ability as a colonizing people, in so far as colonization is to be regarded as an aid to the progress of the colonizers, which is the consideration that preoccupies those who regard the problem from this point of view. Let us put this question aside since it has no immediate relation to the problem of civilization which is now occupying our attention. Although this is interesting to economists and to

[1] The defense of Spain's colonial policy in America has been very incomplete. Neither Vargas Machuca nor Solorzano nor Nuix, etc., has dealt for the most part with more than one aspect—*i.e.,* the slaughter of the Indians, their slavery through the abuse of agents, and other matters connected with the accusations of Las Casas; and even this they have usually done with arguments which, judged by our modern standards, at times rather make things worse, although such arguments carried great weight at the time they were advanced, because they were in accordance with the legal opinion of the age, a circumstance which we must never fail to take into account. As an example of this type of argument we may take that of evangelization and that of the power of the Pope, which Vargas Machuca employs, etc.

those who with scientific reasoning deduce from every manifestation of a people's character the salient points of their psychology and their fitness for social life, it lacks interest for those who, like us, are putting a very different question —one referring not to the effect of colonization upon the colonizing country, but on the country colonized.

In this respect it is not particularly interesting to note those cases in which the Spaniards of the sixteenth and seventeenth centuries, as sons of their epoch and educators in its ideas, acted as did the world at that time (and as is done even to-day quite frequently) toward the persons and possessions of the natives, their political independence and peculiar civilization, more or less advanced. That which is both interesting and necessary is to note and weigh, after a detailed and calm investigation, the true extent of this proceeding, or, in other words, of this contempt for the Indians and the abuse of their lives and possessions, in order that we may be able to say whether the cases in which this occurred were such, in number and consequence, as to warrant our considering the Spanish conquest and colonization as a unique and extraordinary example of a cruelty and arbitrariness unequaled in history, or, on the contrary, an example of the manner in which human groups which consider themselves more advanced have always treated those inferior to them. And while we are considering those charges unfavorable to Spain, it is equally interesting and necessary to ascertain and scrupulously to judge those actions, laws, sentiments and ideas which counteracted to a certain degree, or attempted to counteract, the usual method of formulating and carrying into effect a system of treatment for peoples of different rank in the scale of culture and civilization, peoples of different religion, etc., etc. The accurate and complete verification and comparison of these two opposed points of

view will enable us to form a just and impartial judgment upon Spain's early proceedings with regard to the countries which she conquered or colonized. This verification of data, however, has not yet been carried out, although it has been suggested and even initiated in certain historical and polemic works, modern and ancient.[1]

The same reaction which is visible to-day in the works of so many authors, not Spaniards, against that exaggeration, admitted and encouraged for centuries, concerning Spanish cruelty as an essential part of our methods of colonization, proves that the matter is not yet fully understood nor the final judgment upon it rendered. The thousands of comments dealing with American history which have not been read and, consequently, not been used in historical investigations are sufficient argument in favor of a just and prudent hesitation in pronouncing this judgment.

There is to be considered, however, a second division of this purely historical problem which is occupying our attention at present. This division deals with the actual benefits conferred by Spain upon the countries she colonized. Mistaken or not, from the point of view of politics, the comparison of the Indies (Spanish possessions in the New World) to Spanish territory, the consideration of their inhabitants as Spanish subjects, which influenced the laws given to them in the same manner as it influenced those given the people of the Spanish peninsula, the frequent transplantation of Spanish institutions to America, the participation in public duties allowed these very natives, etc., etc., are facts which merit consideration as evidence that Spain gave to the new countries she had conquered the same political and administrative system by which she herself was governed,

[1] A résumé of all that is known on this subject to-day may be found in the author's "Historia de España y de la Civilización española," Vol. II, secs. 574, 575, 588; Vol. III, secs. 676, 677, 678, 695, 696, 697, 698; Vol. IV, sec. 811.

and not a distinct and inferior system.[1] She also followed this identical policy with regard to her culture, establishing in her colonies the same system of education which the mother country possessed and which experienced the same fortune and vicissitudes as did the latter. In this respect there never existed a system of exceptions (we refer to the classical period of colonization), but rather one of perfect equality. For the native races and the half-breeds Spain even went to the extent of founding special centers of education and means of obtaining it (as, for example, in Cuba, Mexico and Chile). If she did no more, and if she did not always succeed in that which she attempted, this failure was due either to the fact that the problem of popular education, as far as the native was concerned, did not at that time present itself with the same clearness and urgency as it does to-day, since culture was then the patrimony of a select class,[2] or because in the mother country herself they either knew no better how to deal with the subject, or if they had at one time known, the decadence of education had greatly reduced this knowledge. Failure was never due, however, to lack of interest in offering to the colonies all that Spain herself possessed of culture and of education.[3]

When the Spanish governor failed to observe the general rules of the original policy in reference to government and instruction in the colonies, curtailing the rights of the creoles to hold public offices and reducing their opportunities of seeking prosperity through the liberal professions[4] because

[1] For references on this subject, see the references quoted in the preceding foot-note.

[2] Concerning the aristocratic and narrow field of education, one may consult the author's "Historia de España y de la Civilización española," Vol. III, sec. 745.

[3] "Historia de España y de la Civilización española," Vol. III, sec. 774; Vol. IV, sec. 837.

[4] In this respect one recalls the typical case of Don José Perfecto Salas (eighteenth century). "Historia de España y de la Civilización española," Vol. IV.

he distrusted the use to which they might turn those advantages, the situation changed and the conflict with these descendants of the Spaniards themselves, *not* with the native Americans, declared itself. This conflict, for the causes indicated above and for many others extremely complex, was at its bitterest during the nineteenth century with respect to those colonies which remained in the possession of Spain until the close of that century. This change, which was so late in appearing, has, nevertheless, not been thoroughly studied either in its scope or causes, and consequently it is impossible ever to estimate, with any degree of exactness, its historical importance and bearing upon the problem of this paper.

Finally, the study of Spain as a colonizing power would be incomplete, from the point of view from which we are now considering our question, without a realization of the discoveries and contributions drawn from the opportunities afforded by her colonies and added by Spain to the general fund of the world's culture. The services rendered in this respect by her geographers, cosmographers, naturalists, philologists, navigators, etc., make a considerable item which justice demands that we place to the credit of Spain in the general work of civilization—that is, in the list of contributions which each people owes this work in proportion to the resources with which its history shows it to have been endowed. The just consideration of this point must wait, as does all that precedes it, until historical investigation has ascertained the number, quality, and significance of the facts relating to it.

Let us now return to the general question from which this digression, or rather this practical application, has led us and which most concerns us since it relates to the fundamental structure and scientific purpose of these lessons; in other

words, let us return to our study of the ways in which civilization is communicated or initiated or encouraged among peoples which either fail to possess it at all or possess it in a tentative and elementary state. Without discussing again all the points which we have examined, let us accept the law, just as history past and present shows it, that the peoples superior in culture, wealth and power, and animated by the desire to extend their influence over the world, always intervene in the affairs of other nations which they consider inferior. This interference, however, is undertaken under the pretext or with the sincere intention of aiding a more backward people toward progress through the infusion and transplantation of all the means of culture and of comfort, of the methods and standards of conduct which had aided the intervening nation in becoming a principal factor in all the history of the world during the epoch of its greatest power. And let us imagine the most favorable case—namely, that in which compulsion is limited to the indispensable (a case in which force is used simply to bring the nation under tutelage to submit patiently to the educative action in all its branches), and where this compulsion is actuated solely by purposes of kindness, coöperation and aid. Even then a new problem of unquestionable importance would arise because it concerns the future civilization of the world. This problem is that of the relation which the distinctive characteristics of the educating and educated nations should bear to each other, not so much in the field of politics as in the more fundamental and important field of the culture and philosophy which each nation represents.

The problem is neither useless nor purely hypothetical. On the contrary, it deals with a very common reality which repeats in ethical relations that which constantly appears in the relations of individuals, especially where these relations

enter the field of education. In all grades of instruction there are educators who understand their function as simply one of causing absorption. This interpretation of their duty is sometimes due to a sincere pedagogical opinion, sometimes to a vanity which considers its own culture ultimate perfection and for that reason worth imposing upon others and repeating without the slightest variation or amendment. Such instructors consider that they have faithfully performed their task if they have reduced to the same pattern the minds and characters of their pupils, giving them a single model and smothering in them all manifestations of originality and individuality in order that no one shall either mar or improve the picture. In this same way there exist "absorbing" peoples who understand their duty toward civilization not in the sense of an obligation to arouse and stimulate the free spirit of others, so that through original and unhampered impulse they may attain, in their own way, the highest ends of human endeavor, but in the sense of imposing upon others their particular conception of life and manner of complying with its demands; thus replacing with their own spirit that of the nation they desire to advance—that is, practically crushing this nation out of existence by destroying its national spirit and replacing it with that of the educator. Historical accuracy compels us to admit that not merely some but the majority of colonizing and civilizing nations proceed in exactly this manner. We must also admit that those who have entered foreign territory with the frank desire for conquest have been more justified in so proceeding. This impulse of absorption, this lack of consideration for the mentality and character of other human groups, sometimes results from the instinctive and irrepressible force of the civilizing spirit, which, endowed with overabundance of strength, wherever it appears destroys everything less power-

ful, even without the deliberate purpose of so doing; at other times it emanates from the excessive and inflated estimation which a nation holds concerning its own accomplishment, and from the corresponding contempt which it entertains for the accomplishment of others, in which, indeed, it perceives only those things which call for reform or abolition. In any case, however, the spirit of absorption springs from a lack of sociological and educative orientation caused by ignorance, or at least by the lack of a realization, so complete that it is formulated and applied in a line of conduct, that education produces nothing of worth while it is limited to transferring from one mind to another formulæ and bits of second-hand knowledge, as one pours water from one vessel into another, but is only productive of results when the pupil's own intelligence is stimulated by examples, by suggestions, and by the assistance of his own judgment, which has been encouraged to attain a higher degree of ability to comprehend life and the manners of satisfying humanity's needs, both material and spiritual.

It is interesting to note that this neglect or faulty comprehension of the educational duties of one people toward another has been increasing and growing more prevalent as civilization has advanced. The enormous difference between the civilization of the Greeks and Romans and the primitive, barbarous state of the other European nations which they colonized and ruled explains, on the one hand, the contempt of the former for their colonies, and, on the other, the admiration which the inferior nations felt for the superior, and their eagerness to assimilate the higher culture of the latter. But we must also notice that the Greeks and Romans (we restrict ourselves to the history of European civilization) deliberately refrained from attempting to surpass or restrain any characteristic manifestation on the part of the nations

which they colonized and dominated, except, of course, as these manifestations might relate to politics and government, because this would have concerned their sovereignty. For the rest (religion, mode of living, private and even, in part, public law—all those things in which the distinctive characteristics of a people are most clearly shown) they had the greatest respect, or, one might say, since "respect" does not exactly convey my meaning, the greatest indifference. By virtue of this indifference each people was enabled to preserve and perpetuate these important institutions in their original form and purpose. Rome had to attain the height of her power in order that Romanization as an absorbing force (certainly not repugnant to those subjected to it) might extend to matters originally left untouched, but in which, as a matter of fact, the dominated peoples possessed little that was definitely opposed to the innovation of the conquerors. Only religion was exempt from this uniformity (and perhaps also a part of customary law), although this freedom was without great advantage to those nations whose religion was really less advanced than the Roman paganism, and, more particularly, than the philosophy which was gradually replacing this paganism.

Christianity changed the aspect of affairs by transferring the process of absorption to the religious side of the question. The Germanic peoples, Romanized more or less thoroughly and rapidly and upholding in the field of law the principle that each nation should possess a code suited to its own peculiar conditions and demands, represent only as regards religion the uncompromising uniformist attitude of mind which, notwithstanding the indifference of the Mussulmans in the majority of cases and the spirit of practical compromise which some Christian nations maintained toward them and toward the Jews for many centuries, was

imposed from the twelfth century, and which grew constantly more bitter and severe until the early part of the present age. In other things, however, the conquerors and the colonizers returned to the practice of the Greeks and Romans, and did not insist upon the suppression of the customs and manners peculiar to the inferior peoples as long as these did not infringe upon the question of religion and, as goes without saying, upon the matter of their own sovereignty. Either they left their subjects in freedom upon all other subjects (without this neglect in any way preventing the realization in history of that spontaneous assimilation of superior culture which penetrated everywhere, and which, through imitation, communicated to the inferior race that part of itself which they were capable of adopting), or they made them their legal equals, placing within their reach, as they did in Spain, all the means of culture and progress which the mother country possessed. It must be observed, too, that all this was worked out with peoples in a very primitive state of civilization both socially and intellectually, or even in a state of manifest barbarity.

But to-day the doctrine has taken a new turn, and it is applied in dealing with all classes of peoples. The endeavor of those who uphold it would be to eradicate from within the limits of their political dominion every type of civilization and manner of living which differs from their own, and to replace them with a new expression of their own doctrine of intransigency, which, if it spares religion, affects other phases of life as essential and characteristic, and which is, after all, no more than an expression either of colossal vanity or of inconceivable short-sightedness with regard to the way humanity has progressed and can still continue to progress. The effective mode of progress which, in obedience to a psychological law stronger than human will, the

peoples of all ages have followed, working together for the perfection of civilization as a whole, in spite of humanity's tendency toward jealous anger and the formation of distinct and self-sufficient groups, is not one in which a single philosophy of life and manner of giving expression to mental and spiritual qualities forces into one mold, with deplorable monotony and unjustifiable tyranny, the various activities of peoples; rather is it one in which each people develops its own culture to the highest point, extracting from each mental trait and quality all that it offers of essential and valuable in order thus to enrich the complex whole of life with customs varied and distinctive (in so much as they are unique and represent the peculiar aptitudes of each people). To proceed in any other way—that is, against this principle of consideration of complete and unhampered cultivation of the individuality of each people—is to impoverish civilization. There exist, without doubt, examples of the above-mentioned mode of progress, notably in industrial applications of the great scientific principles—that is to say, applications of our knowledge of natural forces and their laws which, through their very generality, are applicable to all and which all are equally free to use. This also is the case with universal, humanity-wide principles of education and moral conduct. But, on the other hand, there are many qualities of the spirit, or appertaining to it, which fail to develop in all peoples or in all individuals. Each one has been or is master or master artisan in one or various lines of progress, and his accomplishment is offered, in the course of centuries, as a model and spur to others who would not know how to surpass it, and who need, from time to time, to stimulate their energies by contact with an achievement which through its very nature has attained the highest degree of perfection of which humanity is capable. Each particular "civilization" of those

which arrive at productive maturity has contributed its characteristic item. This contribution is the outcome of the coalescence of the most fundamental, most distinctive qualities of the people or the peoples which produced it, and it will always endure as a model for the later civilizations, which, influenced by their own idiosyncrasies, may advance along quite different lines. In this manner civilization has continued to progress through the assimilation of the multitudinous factors which compose it to-day. Each of these factors has had, or has, its most perfect and characteristic form in the achievement of a single people, for the qualities and aptitudes which are called forth by human needs, from the most elementary to the highest, have not been and never will be united in one spirit, national or individual, but distributed among many.

This being the case, what would civilization gain if even one of these contributing factors were destroyed? And what more would she gain if *all* but one were destroyed in order that this *one* might dominate the world, subjecting it to a uniformity which would carry with it unforeseen limitations? No one is great or perfect in everything, but only in a very small portion of those things which his life demands of him if he is to be worthy and humane. What will he do, then, without the collaboration of those who can supply the notes which the lyre of his own spirit lacks, or from which, even if they are beneath his fingers, he is unable to produce as deep and full a vibration as is he for whom these same notes sound as spontaneously as the laughter of a child or the song of a happy man? Our human egoism lies in the very fact that we do not lack any collaboration in the task of bringing together the richest variety of essential notes. But to accomplish this we must realize, in the first place, the value of them all. We must make each nation, each people,

understand its unavoidable duty and grave responsibility toward the cultivation and perfection of its own distinctive note in the great harmony of civilization. In other words, each people must learn not to flee from the task set before it, nor to fail in that assistance which other people expect from it. It is also necessary to establish a continuous and systematic spiritual communion among nations in order that they may understand and mutually aid each other, that each one may learn from the rest the lessons they are best fitted to teach, and that in this way the work of national civilization may be converted into a truly human work in which all groups and all individuals may coöperate, each contributing the best and most valuable part of its culture, and each bearing always in mind the way in which his contribution will most benefit others.

Only in this manner should civilization spread, perfecting and enriching itself,—civilization, with the present and future of which we are rightly concerned, and the laws of which historians and sociologists do not investigate from mere curiosity alone, but rather in order that their knowledge of these laws may enlighten and guide mankind in all its present and its future actions.

RAFAEL ALTAMIRA.

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CONTENTS

MUTATIONS IN HEREDITY[1]

SINCE the publication of the two volumes of my "Mutation Theory" ten years have elapsed. At that time the prevailing opinion was that very small and often even invisible changes could gradually be increased and accumulated, and that this process could lead to specific differences, and even to the production of the characters of genera and larger groups. This conception was the principle of the theory of selection as proposed by Darwin, as well as the starting point for the hypothesis of orthogenesis, of the direct influence of environment, and of many others. It was generally accepted in the teachings of plant improvement in agriculture, and, as a matter of fact, the origin of new varieties by leaps and bounds was a fact well known only to horticulturists.

In opposition to this conception, I tried to show that the origin of new forms complies, in nature as well as in agriculture, to the mode which was observed to be followed in horticulture, and that the whole evolution of the plant kingdom has been brought about by a long series of successive small leaps. The extraordinarily slow evolution which was a necessary consequence of the then prevailing opinion required an almost unlimited duration of time; but the new principle of mutations reduced the biological time to the limits which had been determined by physicists and geologists for the duration of life on this earth. The starting-point for the new ideas was the distinction between two main types of

[1] A lecture delivered at the inauguration of the Rice Institute, by Professor Hugo de Vries, Director of the Hortus Botanicus and Professor of Botany in the University of Amsterdam.

variability: fluctuation and mutation. I had deduced this principle from my interpretation of Darwin's well known provisional hypothesis of pangenesis, and convinced myself of its truth by means of a series of experiments. On the basis of these theoretical considerations I proposed the mutation theory, which means that the characters of all organisms are built up of sharply distinguished units. These qualities may be combined into groups, and in allied species the same units and groups may be met with. They do not pass gradually into one another; transitions fail between them, although they may often be observed between the external forms of plants and animals.

The changes in the number and the position of these units, as well as those in their relative connections, constitute the domain of mutability. They are the causes of discontinuous variation, or of the sudden appearance of externally visible deviations. The steps are, as a rule, only small ones; but are inherited as such from the very beginning, without transitions. Apart from these, the different organs and qualities continually vary in number as well as in measure and weight. In doing so they are observed to follow the laws of probability and to be influenced by external factors; favorable conditions may increase them in one way, while unfavorable circumstances may determine their augmentation in the opposite direction. Such changes are described as fluctuations or as fluctuating variability. On the basis of the investigations of Quetelet, their laws have been very completely studied. All these phenomena are governed by internal as well as by external causes. The internal ones are given by the hereditary units and determine the nature of the changes which may take place; while the external factors decide when and to what extent the deviations from the average will occur.

As well as fluctuations, mutations are induced by external and internal causes, as I have distinctly pointed out. The determination of these, however, is far more difficult than in the case of fluctuations. It is only in a general way that my experiments show that mutability may be increased by favorable conditions of life. In connection with this fact, we may assume that, in nature, the origin of new forms is not due to a hard struggle, but is promoted by a luxuriant environment and by easy conditions of development. It is true that a struggle for life must be; but this comes in after the new forms have already been produced, and, as it seems, often only after a considerable lapse of time. Such a struggle for life demands no greater sacrifices than those which are unavoidable, even under the common conditions of the field; while in the old selection theory the sacrificing of thousands of lives was required for every step in progressive development.

In the last ten years the principle of character units has gained a firm hold for itself in evolutionary science. It has transferred the problems from the domain of speculation to that of experiment, and has brought the teachings of Mendel (which had been disregarded up to that time) to universal acknowledgment. The generally accepted view of the continuous intergradation of characters into one another had for a long time been in the way of a broad appreciation of the merits of the principle of Mendel; but the theory of pangenesis has led me to experiments in hybridization which fully confirmed the results of Mendel, and clearly showed their high importance. Moreover, the lines of research laid down by Mendel proved to be of easy application to an almost unlimited number of cases, and so the study of the last ten years has turned in the main to them, and thereby to

a great extent neglected the direct investigation of the origin of new forms.

The theory of mutation is not intended to take the place of the theory of selection of Darwin. It is only one step further in the development of our appreciation of evolutionary phenomena. The problem of the theory of selection is the explanation of the overwhelming richness of living forms in nature. It has succeeded in bringing this under the grasp of our understanding; but it has the disadvantage of easily conducing to poetical speculations whenever one tries to apply the general views to single cases. In such cases many authors are content with hypothetical descriptions of what the relations of the phenomena may be supposed to be. Contrary to this method, the theory of mutation deals with the problem of the origin of the material from which natural selection chooses. At the time of Darwin the distinction between fluctuation and mutation had not yet been discovered; but as soon as this was the case it was clear that only the latter process could supply the material for further selection. This principle at once got rid of numerous difficulties which up to that period seemed to be inherent in the teachings of Darwin.

Among those who supported the new theory in its first years, although with some reserve, I cite in the first place Strasburger, who wrote as early as 1902 "that the formation of species does not start from fluctuating variability, but from mutations," and that especially "for the place of an organism in the natural system the degree of development reached by all the successive mutations is decisive."[1] He was soon followed by the larger part of the botanists, although many among them took exception for the adaptation of species to their environment.

[1] "Jahrb. f. wiss. Bot.," T. 37, 1902, p. 518.

Among paleontologists, Charles A. White was the first to take publicly the side of the theory of mutation,[1] and the most prominent representatives of this science soon adhered to his ideas. It might perhaps be said that in no other domain has the new principle been so rapidly and so generally acknowledged. Here numerous facts are in evident contradiction to the idea of an extremely slow evolution among fossil plants as well as animals. Other facts clearly show "that the degree of mutability of species has not always been the same during the geological periods of their existence, but is evidently subjected to changes" (p. 638). This sentence corresponds exactly to my conception of periods of mutability. Life before the Cambrian times is wholly unknown to us; but in this period all the main branches of the animal kingdom at once make their appearance, with the exception of the vertebrates only. Only by means of very complicated hypotheses could the old conception explain these broad facts. Among the floras of all times that of the Carboniferous period has without any doubt been by far the richest; it appeared suddenly, and afterward disappeared almost at once. Many types of organisms have escaped the changing influence of natural selection during a long succession of geological times, as, for instance, the genus *Unio*, which has come to us almost without any modification from the Mesozoic period. In the Tertiary layers of Florida, Dall has pointed out the occurrence of numerous forms which have come over from one period into the succeeding one, and which are still in part among living species. The evolution of the pedigree of the vertebrates during Tertiary times has been an exceedingly rapid one—by far too fast to be compatible with the old view of slow improvement. The same conclusion holds good for birds, for fishes, for

[1] Smithsonian Report for 1903, pp. 631–640.

phanerogamic plants, and for quite a number of smaller groups. All in all, the geological facts plead against a slow and for a relatively rapid evolution, thereby justifying the conception of modification by leaps. Such were the arguments of White, but it would take me too long to cite them in all their details.

In the domain of zoölogy the old and the new conception are still sharply opposed. The new ideas easily comply with the celebrated theory of Hubrecht concerning the evolution of the pedigree of the vertebrates, and the author of this view has more than once vigorously supported my ideas. On the other hand, Plate is still among the adherents of the validity of the unmodified theory of selection.

In the field of agriculture the new conceptions are found to be in full harmony with the experience of Hjalmar Nilsson, the director of the Swedish agricultural experiment station at Svalöf. By means of elaborate experiments this investigator has shown that a selection of fluctuating differences has no value at all for the improvement of agricultural plants, especially cereals; and that all breeding of new races must start from a careful choice of the best among the elementary races, which are found in the present cultivated varieties. The unexpectedly large results which this method has rapidly produced have gained for it a general acknowledgment in agricultural circles, and the principle of slow improvement of races has since been replaced almost wholly by that of the choice of single mother-plants (*"enstaka moderplanterna"*) and of the cultivation of pure races from their seed.

But still there is always much discussion and much opposition, and therefore it may be useful to give a short review of the main arguments which seem to plead against the new theory. Before doing so, I might, however, point out two

volumes which, from different points of view, deal with almost all the questions which are still open in this field and give a fair appreciation of the arguments brought forward by different authors. One of them is a German treatise on "Abstammungslehre" by Buekers[1]; the other, a volume in French on "Transformations brusques des êtres vivants," written by L. Blaringhem.[2] The first of these two books deals mainly with the questions from a critical point of view, and is very exhaustive in this respect; while Blaringhem supports his opinion by a thorough study and accurate description of a number of new mutations which occurred in his cultures.

Some authors have asserted that the theory of mutation has been deduced from the doctrine of hybridism. Others have pretended that my experiments with the evening primrose of Lamarck were its starting-point. Both these opinions are erroneous from the historical point of view as well as from a logical one. The mutation theory originated from the hypothesis of pangenesis.[3] This hypothesis suggested to Darwin the principle of the units which he called gemmules. Every one of these represented, in his opinion, a visible part of the organism, even of a single cell.

According to my conception, the units correspond to the qualities by the coöperation of which the whole character of the organism is built up. Each of these units may express itself in different parts of the individual. It is from this conception, as stated above, that I derived the hypothesis of the two main types of variability. In order to control this deduction by means of experiments, I studied, on the one hand, variability itself; and, on the other, hybridism. The

[1] Dr. P. G. Buekers, "Abstammungslehre," Leipzig, 1909, § 354.

[2] "Bibliothèque de Philosophie scientifique," Paris, E. Flammarion, 1911.

[3] See A. A. W. Hubrecht, in "Popular Science Monthly," July, 1904, p. 222, and V. Haecker, "Allgemeine Vererbungslehre," 2e Aufl., 1912, p. 287.

first of these two groups of experiments included over a hundred different species, some of which showed signs of mutability, while by far the larger number did not. A small degree of the propensity to produce new forms was observed in *Linaria vulgaris, Dahlia variabilis, Chrysanthemum segetum* and *Dracocephalum moldavicum*. Among all the species studied by me, I found, however, only a single one which showed the new quality in quite a large degree, producing new types almost every year, and thereby stimulating to an extensive as well as intensive study. I supported this inquiry by a critical review of the numerous facts scattered through the literature in the fields of agriculture, horticulture, teratology and other sciences; and, almost at the same time, the whole range of observations which pleaded for a sudden origin of cultivated varieties was exhaustively collected by Korshinsky from the horticultural literature.

Another widely distributed error is the opinion that the theory of mutation is opposed to the principle of selection. It is even asserted sometimes that the theory of selection should have been replaced by it. I have already pointed out that the real service done by Darwin to evolutionary science lies in the proposition of his principle of explaining the development of the organisms from one another, in its main lines as well as in its details, on the basis of well ascertained facts only. His means to reach this aim were the struggle for life and the survival of the fittest—or, in one word, natural selection. The question whence the material for this selection was derived was of course duly and fully dealt with; but our knowledge of the phenomena of variability was at that time still in its infancy, and far from being adequate to the demands Darwin made upon it. This was the reason why he did not succeed in convincing his contemporaries. It is only on this weak point that the theory of

mutation has to come in. Its aim is not to be sought in the explanation of the different forms of life. It starts from the principle that the changes which find their expression in variability are intrinsically connected with the germ-plasm; that they are provoked within this substance before fecundation, either in one or both of the sexual elements, and come to light only afterward, during the development of the new individual. Although evidently dependent on external factors, such as nutrition, etc., they are not each related to these in such a manner that it would already be possible for us to explain this dependency in its details. The older and some of the still prevailing theories consider that the changes take place first in the growing or even in the adult organs, and are only transferred afterward to the sexual cells.

From a general point of view, the chances of a new idea finding adherence often depend in a great degree on its applicability to other fields of inquiry besides its own experimental domain. General considerations are often more decisive than pure facts. In this respect the mutation theory has the great advantage of easily complying with the most widely divergent conceptions of the phenomena of adaptation. It may be combined with these even more intimately than the older views, as I shall show later on.

The empirical basis of the new teachings is the distinction between fluctuation and mutation. The first is the ordinary form of variation, often called individual, gradual or continuous variation, and well known to Darwin himself. It is almost always and everywhere active in a lesser or in a greater degree. Mutation, on the other hand, is a rare and most sporadic phenomenon only rarely occurring in groups, but by means of it new types are seen to arise suddenly, sharply, although often not widely distinct from the parental type. With this proposition many authors have since ex-

pressed their agreement, and in one of the newest manuals Karsten summarizes the now prevailing conviction by saying, "Spontaneous variation or mutation is sharply distinct from fluctuation, since it proceeds by leaps and at once produces hereditary differences."[1] And even the most ardent opponent of my view,—Plate—in concluding his lecture on "Inheritance and the Theory of Descent," says that "phyletical evolution is discontinuous in the changes of the determinants, although ordinarily continuous in its external display";[2] and in doing so he evidently concedes the main point in discussion.

Fluctuations are quantitative variations, but mutations are of the qualitative kind. Under the influence of selection, the first do not produce constant races which become independent from that selection, while the products of mutation are at once of an hereditary nature and constant. This principle has brought the study of elementary species into the first rank of biological interest. The investigations of Jordan, de Bary and many others had not succeeded in convincing biologists and systematists of the truth that the species of Linnæus are in reality collective entities, and that the real units of nature are the so-called small species. It is quite evident that it is impossible to observe the origin of such a collective species, since the conception is partly, at least, of an artificial nature. But now the origin of the small species has become an object of direct inquiry. One of the oldest objections against the theory of descent has thereby been surmounted forever. Even in the field of pure description the new ideas have their influence. It is conceded that even the so-called type specimens might not be homogeneous

[1] Nussbaum, Karsten und Weber, "Lehrbuch der Biologie für Hochschulen," Leipzig, 1911, p. 295.

[2] L. Plate, "Festschrift zum sechzigsten Geburtstage Richard Hertwigs," Bd. II, 1910, p. 607.

if they are based on different individuals collected in the field. Small differences of the nature of those existing between elementary species might occur among them and sooner or later become the source of misunderstanding. A pure prototype can evidently not be secured in this way, or at least its purity cannot be guaranteed. Starting from these considerations, Kellerman and Swingle have lately pointed out the necessity of taking all the type specimens for one species from one single individual, and proposed to distinguish those which comply with this principle by the name of merotypes.[1]

One of the greatest difficulties of the theory of selection as worked out by Darwin is found in the fact that changes which after some degree of development may be advantageous to their possessors cannot be of any use to them at their first appearance as almost invisible deviations from the old type, and even during a long period afterward. Notwithstanding this, the theory requires their being selected from among the others, and this on the ground of their usefulness. This objection has been dealt with exhaustively by a large number of authors; but in the last ten years all of them agree in conceding that it has been successfully met with by the principle of mutation.

One of the main supports for the ideas of Darwin was a comparison of selection as used in agricultural practice with the corresponding phenomena in nature. Unfortunately, the descriptions of their procedures given by the leading agriculturists were far from adequate to the use Darwin wanted to make of them. On the one hand, he succeeded in proving the analogy between artificial and natural selection by heaping up an overpowering material of facts, and it seems to me that this proof has been one of the principal factors in the

[1] Journal of the Washington Academy of Sciences, Vol. II, May, 1912, No. 9, p. 222.

victory which his theory has so completely gained. But the agriculturists themselves did not clearly understand their practice, and even partially explained it in an erroneous way, and these errors were transferred unobservedly to the theory of natural selection. It was only a critical study of the classical and thoroughly scientifically conducted cultures of Rimpau in selecting his rye which yielded a satisfactory, although belated, understanding of the whole phenomenon.[1] I found out that Rimpau, although believing he was selecting only the richest ears from among a uniform race, in reality chose the best elementary species from a motley mixture of types. From the progeny of his handful of chosen ears he subsequently eliminated the minor ones, until by means of a selection of some ten to twenty ears he finally reached a pure race, which, according to our present conception, must have consisted only of the progeny of the very best one of the ears he chose in the beginning. Such a pure race was no longer exposed to reversions, and this has been thoroughly proved in the case of the rye of Rimpau by the cultures of Schribaux in northern France. At present the principle is universally recognized. We may safely transfer it to the comparison of artificial and natural selection as proposed by Darwin, and conclude from it that Nature herself does not select her new species from fluctuating variations, but from the existing small types, or, in the end, from mutations that occurred at a previous time.

I now come to a consideration of the two principal theories which have secured for themselves quite a number of adherents and are still defended by many authors as auxiliaries of the old theory of selection. I mean the principles of orthogenesis and neo-Lamarckism, or the theory of direct influences. The former of these refers to the main

[1] Proceedings, American Philosophical Society, Vol. XLV, 1906, pp. 149–156.

lines in the pedigree of the animal and vegetable kingdoms, the latter to the adaptations in the ultimate branches of these pedigree trees. In my opinion, neither of them is opposed to the teachings of the theory of mutation, especially since they are destined for quite another field of phenomena.

This is clearly shown by the curious circumstance that the adherents of orthogenesis recognize the validity of the new theory for the explanation of adaptations, while the neo-Lamarckists declare it to be valuable only for the origin of the larger branches of the system. All of them recognize the process of mutation as the normal mode of origin of species, and make an exception only for the field in which they are especially engaged.[1]

Before continuing this discussion, it is, however, necessary to deal with the distinction between characters of organization and those of adaptation as proposed by Nägeli. The former are the marks of natural families and of higher groups; they have been evolved in very old geological times, and our knowledge concerning the climate and the life conditions of those periods is necessarily limited to a general outline and does not justify us in making a distinct idea of the environmental conditions of the single species and of the claims made upon them by the struggle for life. Therefore it is hardly possible to deal with the causes of their evolution and of the origin of new types of life with any higher degree of probability than that of more or less poetical descriptions.[2] These characters of organization are often supposed to have originated in a manner essentially different from that of the characters of adaptation. In the former case,

[1] Von Wettstein, "Handbuch der systematischen Botanik," 1901, p. 36; Strasburger, "Jahrb. f. wiss. Bot.," 1902, T. 37, p. 518 u. A.

[2] This expression is not meant to include the least reproach. On the contrary, I myself often prefer using such forms of speech, trusting that my readers will recognize them for what they are intended to be. Critics who failed to see this point more than once have given me great amusement.

internal causes are assumed to be the most essential factors; while in the latter this rôle is given to the external conditions.

Adaptation is limited to the very youngest qualities of animals and plants, and this is carefully pointed out by the most prominent among living neo-Lamarckists, von Wettstein. He says, "As far as experience goes, we may assert that by means of direct adaptation nothing absolutely new is produced but that its results are in the main directed to an augmentation or a diminution of properties already present." And to this sentence he joins another, which eliminates all possible doubt, and which says that, after long times of direct adaptation and after the disappearance of such transitional forms as it may have produced, "the impression of an essential deviation" may be made upon us.[1]

From this discussion it is clear that the characters of organization and adaptation do not cover the whole field of systematic differences. The former are limited to those between the larger groups; and it is characteristic of them that they do not show any relation to the struggle for life—at least not at the present time. The characters of adaptation, on the other hand, are the marks of the youngest of all the systematic groups, and are, as a rule, limited to species and subspecies. Between the two divisions there is a wide gap; but this field includes, curiously enough, exactly those cases which are the most interesting ones for the great principle of evolution. Large, and therefore, at all events, not very young groups, like most of the cactaceous and euphorbiaceous plants, in many cases show the most beautiful and stringent arrangements for a life under strongly specialized conditions. These, however, are to be included neither with the marks of organization as described by Nägeli, nor with those of adaptation as proposed by von Wettstein. There-

[1] R. von Wettstein, "Handbuch," *l. c.*, p. 44.

fore it seems unavoidable to collect them into a new division, for which it seems practical to choose the name of *characters of specialization.* For the cases to be covered by this expression are taken from plants which show a high degree of differentiation on very special lines; and the question whether this is useful or only innoxious to them is one which it is at best hardly possible to decide on a purely empirical basis. But on the layman they make the impression of the most beautiful adaptations.

Warming has distinctly pointed out that the real nature of orthogenesis, as well as of direct influence, is not clear to us. The latter of the two principles assumes an intimate correlation between the external factors and the usefulness of the deviations produced by them, but in Warming's opinion this relation is "of obscure nature."[1] Therefore it seems justifiable to assume that this direct influence is not a single mystic force of nature, but the result of the combination of a larger or lesser number of such forces. But in this case it must be possible to make an analysis of them, and it strikes me that the theory of mutation is capable of supplying us with precisely the necessary means for this purpose.

The same reasoning and conclusion hold good for the principle of orthogenesis. Concerning this Coulter says: "Long ago it seemed possible to consider it to be 'a mysterious principle inherent in organic life,' or as an internal force which determined the direction of variability; but in our time, since the rôle of environmental conditions and the whole group of external factors have come into the foreground of biological interest, this conception can no longer be considered as sufficient. But, at all events, we hardly know how these external factors really influence evolution,

[1] Warming, "Ecology of Plants," 1909, p. 370.

and which is their true nature."[1] And in connection with this he remarks that natural selection, mutation and orthogenesis are far from excluding one another.

Let us now consider these three groups separately. In the case of orthogenesis we may limit ourselves to two points. First, the suggestion that it is not variation, but selection, which has been working in the same direction during long geological times. And although, as already pointed out, we know very little about the factors of the struggle for life in those remote times, this question seems to claim full appreciation. If we decide for a continuity in the selection, variability may be assumed as occurring in indistinct directions, even at those times. If, however, we take the opposite point of view, it remains an open question whether the one-sided variability which we must then assume was of the nature of fluctuation or of mutation. And since the former determines only an augmentation or a diminution of qualities already present, we should conclude with the conception of series of mutations taking place in an unchanged direction. This would bring us in line with the proposition of indistinct mutability, since evidently all mutations which would take place in divergent directions would sooner or later have to disappear. Be this as it may, my aim is only to show that, even in such an hypothetical field, the theory of mutation has the best chance of complying with our knowledge of the available facts, without the need of recurring to secondary hypotheses. I have already pointed out that the paleontologists are best prepared to recognize the principle of mutation for orthogenetic evolution. In concluding it seems to me that orthogenesis may best be explained as produced by successive mutations, which themselves have been conducted by orthogenetic selection.

[1] Coulter, Barnes and Cowles, "Textbook of Botany," Vol. I, p. 290.

The conception that characters of adaptation cannot be due to selection, but must be induced by direct environmental influences, was formerly derived in the main from the fact that very small deviations from a given type can have hardly any advantage in the struggle for life, while the theory of natural selection must assume a distinct activity of its principle from the very beginning.[1] As is well known, this difficulty is met with in the most satisfactory manner by the theory of mutation, and on this point almost all authors agree. Different propositions for reconciliation have been made. Thus, for example, the direct influence of the environment seems sufficient to von Wettstein, while Strasburger holds the opinion that it must always be accompanied by selection in order to take its effect. Evidently such an assumption would make the whole theory superfluous.

Two objections must still be considered. In the first place, it should be pointed out that the differential characters on which the diagnostic descriptions of species are based are rarely of the nature of adaptations. In the second place, a most common source of confusion is the lack of a sharp distinction between plasticity and phylogenetic adaptation.

If, in botanical excursions or in determining the identity of collected plants, we have an eye open for the question concerning the meaning of the distinguishing characters for the plants themselves, we must usually concede that they are in reality far from having any real usefulness, or that at least we cannot point out their use if we limit ourselves to purely empirical arguments; for example, *Ranunculus bulbosus* and *R. Philonotis* have the slips of their calyx turned downward; *Myosotis versicolor* opens its flowers before the corolla assumes the blue color; *Viola arvensis* has a calyx which is longer than the corolla; umbelliferous plants are often dis-

[1] Von Wettstein, "Handbuch," p. 39.

tinguished by the occurrence or the absence of a common or a partial involucrum; *Spergula Morisonii* has a narrow membranaceous ring around its seeds; the species of *Taraxacum* and other groups are often apogamous; and so on in an endless series of arguments. What is the use of such qualities? The answer is, as a rule, none at all, since the nearest allies are as successful in their struggle for life without them. This is true in a still higher degree for the distinguishing marks of elementary species, and, as has been pointed out by Willis, for those endemisms which are not relicts but are growing still in the midst of their presumed ancestors.[1] Very often erroneous conceptions concerning the use of distinct qualities are seen to prevail. Thus the red color of many flowers is presumed to attract some species of insects and to find its use in this; but as a matter of fact it is often only a local expression of a quality which may be seen in activity in other parts of the organism as well. Many white varieties of red or blue species are weaker in the struggle for life than their ancestors, and this is the reason why they so regularly disappear very soon after making a local appearance. This struggle for life is not fought out by means of the flowers, but during the vegetative period, wholly independent of the visits of insects and the question of fecundation. This is best seen in perennial plants or in small shrubs where the red or blue flowering forms are often seen to hold their ground, while the white ones are incapable of doing so. I cite, for instance, a culture of *Daphne Mezereum* and of its white variety, both in a number of specimens. The white ones were weak and succumbed to our climate after some years; while the red ones were continually seen to thrive. Between *Ranunculus bulbosus* and *R. Philonotis* it is not those characters that may be studied on dried material which are

[1] See F. Graebner, "Lehrbuch der Pflanzengeographie," 1910, p. 70.

decisive in the struggle for life. On the contrary, the result depends on the predilection of the former for a dry soil, and of the latter for moist meadow-land. Numerous instances of the same kind might be given, and it seems to me that they would exceed by far the number of those cases in which elementary characters, as opposed to compound ones, might be proved to be useful.

Those cases in which the production of new species has been ascribed to the direct influence of the environment may commonly be explained on the principle of mutations as easily as on that of the accumulation of very small and almost invisible deviations.

Seasonal dimorphism is one of the most widely known arguments of von Wettstein. Some plants of the alpine meadows occur in two elementary forms, one of which flowers and ripens its seeds before the summer period of mowing, while the other begins its vigorous growth only as soon as this period is over. At that time, when the great significance and the general occurrence of elementary species were not yet realized, it seemed allowable to assume for this case a special process of adaptation. But, in the light of our present knowledge, the other assumption is at least as fully justified—viz., that the mowing has simply selected, from among a group of preëxisting forms, those which did not suffer by it in the one way or in the other. Unconscious selection would then have acted here just in the same way as conscious artificial selection does elsewhere. In this way the proposition of direct environmental influences may be easily and advantageously combined with the principle of the origin of species by mutation. Species have the power of adapting themselves to the prevailing conditions of life, but they do this by means of the great number of elementary forms of which each of them consists.

The other objection was that connected with the phenomena of plasticity. By this term is meant the power of many species to live under quite different conditions. Not rarely this is associated with striking changes in their dimensions and in other characters; and these differences may be so large as to be taken for specific ones on first inspection. The best known example is that of *Polygonum amphibium,* which has a terrestrial form and a floating one. Some authors have described the former of these as another species and have given it the name of *Polygonum Hartwrightii.* But Massart has shown that by transferring one of the two forms to the life conditions of the other it is always possible to change it into the other type, and that even both types may be developed as branches from the same plant, provided this is growing just at the margin of the water. In the case of alpine plants Bonnier has shown that it suffices to transplant a part of a rhizome into the plain to make the new stems assume the type that is known to be characteristic for the new conditions. In almost all cases where plants may be multiplied in a vegetative way it is possible, in accordance with this principle, to show that their plasticity (which is often called their adaptability) is a latent quality capable of coming into action at once in response to changes in environmental conditions. From perennial species we may conclude that the same must hold good for annual ones too. The capability of many ordinary weeds, which like a soil rich in saltpeter or in other nitrogenous substances, to attain gigantic dimensions under such conditions while they remain dwarfish on poor or dry soil, even in such a degree as to conclude their growth after the production of a single fruit, as, for example, is seen in *Datura Stramonium,* is no doubt one of the most beautiful instances of adaptability; but it is

evident that it does not involve any change in the hereditary qualities.

In all such cases it is clear that the assumed analogy between these adaptations and the origin of new species is only apparent. Qualities may lie dormant for thousands of years, as in the case of the alpine plants, and under changed conditions come suddenly into activity again; they will evidently do this every time that the corresponding stimulus excites them. Without any doubt, many of these qualities are useful, but this does not prove that they have originated on account of their usefulness. The conception that they owe their existence to some mutation, and in this respect follow the general rule, has at least the same degree of probability. In this case no supplementary hypotheses would be necessary. The researches of Costantin, Goebel, Klebs, Stahl, Vöchting, Frank, Karsten and many others have brought our knowledge concerning the phenomena of plasticity to a high degree of development; everywhere it may be seen, however, that the resemblance to the processes of the origin of species has no real signification. Nature often gives us the impression of a most beautiful harmony between living organisms and their environment, and thereby between the latter and their ontogenetic evolution, and it is all too tempting to conclude from this that organisms as a rule have been adapted to their life conditions. This conclusion, however, is in many cases only a postulate and does not rest upon an empirical ground. It goes without saying that animals and plants cannot live under extremely unfavorable or injurious conditions, and that, for this reason, we must find everywhere better or less fitted forms. But, as a matter of fact, most plants are contented in nature with an environment which is far from being the best for them; and where the trade happens to bring their seeds to other countries, they are often seen to

thrive far better and to multiply with unexpected rapidity. It is a curious fact that they are best adapted to conditions which are quite new to them and which they never enjoyed before.

Our third division was that of the characters of *specialization*. It lies between that of the qualities of organization of Nägeli, which have no relation to the surrounding world, and the consequences of adaptation of von Wettstein, which do not produce any really new steps in the line of evolution. Every student must be struck by the fact that the most beautiful examples of so-called adaptations are found in the distinguishing marks, not of species but of genera and the larger groups, even of whole families. In a geological sense they are therefore so old that an appreciation of the single factors of the environmental conditions under which they have originated must necessarily be impossible. As a rule, such adaptations do not consist in a single quality, but in very complicated and highly developed arrangements, which can have been attained only by a series of successive changes. I refer to the flowers of the orchids, to insectivorous plants, to many cases of climbing species, to the tubers on the roots of the leguminous plants, to the *Cactaceæ* and *Euphorbiaceæ* of the desert, and so on. All of them are specialized in a very high degree, and this we assume to be of use to them, at least in many cases. But it seems to me that this usefulness is most liable to overestimation, and in reality consists mostly in a compensation of other hurtful qualities. Later investigations have shown, more than once, that the presumed use does not exist at all—in any case, not at the present time. For instance, let us take the heterostyly of the primroses, which according to Weiss, is more hurtful than useful; or the flowers of *Orchis* and *Ophrys,* which discourage insects rather than invite them to visit, as was discovered by Detto.

The anthers of *Mimulus* and *Torenia,* which contain a large supply of good pollen but never open, must be considered simply a useless waste of material. The *Drosera* has no apparent advantage at all in its ability to catch insects, when we compare its distribution and the rate of its multiplication with that of the species with which it lives; on a rich soil it thrives just as well without the food supplied to it by the insects. The species of *Utricularia* are adapted in the most beautiful manner to capture small animals, but that this should be advantageous to them in their struggle with neighboring plants nobody can prove.

If, however, we concede that they have originated as the result of their usefulness, we do not gain any real understanding of the different factors of these complicated qualities. Neither this assumption nor experience can decide whether the units out of which these qualities have been built up have had their origin in sudden leaps, or in the accumulation of slow and originally invisible changes. In other words, they may be due to mutations as well as to fluctuations, and to the activity of orthogenesis as well as to that of direct environmental influence. From this point of view, there is not the least justification in assuming special supplementary hypotheses for their explanation. The conception that these characters of specialization have originated in quite the same manner as any other distinguishing marks of species as well as of the larger groups has evidently the same right, and perhaps even a greater right, to our appreciation than any special assumption.

Leaving these considerations of a more general nature, we may now return to the experimental side of the question. Here two propositions demand a careful treatment. The first of them is the sentence that fluctuations cannot, by means of the coöperation of selection, lead to constant races,

which should be independent of a continuance of that same selection. The second proposition is the contention that mutations do produce such constant races.

In the realm of selection the first principle is to distinguish sharply between pure elementary species and the collective species of the systematists. On the one hand, we may try to improve the small species themselves by means of selection; on the other, we are concerned simply with a choice from among the mixed groups of already constant and hereditary types. Any doubt which may have existed concerning the reality of this distinction has of late been completely surmounted by the practical processes of breeding which have been introduced by Nilsson into agriculture, and which were founded on his deep scientific knowledge of the problems with which he had to deal. The pure races which he succeeded in isolating from the old mixed varieties of cereals may still produce deviations in the way of mutations or as a result of accidental crosses, but these changes always occur suddenly. It is not possible to improve his strains as such by means of continuous selection. The same is true of many of the older agricultural races which have been won by a more or less unconscious process of selection.

Within the elementary species, artificial selection in many cases may be conducive to real improvements which in a sense are hereditary. In others, however, this result seems not to be attainable. But in any case such races do not become independent of continued selection. Especially instructive in this respect is the history of the cultivated sugar-beets. From a broader point of view, our beets consist of a number of elementary species, and any large breeder has, as a rule, his own kind which he has purified by means of selection. The principle of the culture of separate families is followed. It starts from single mother-plants, and

every family is the progeny of only one such specimen. The possible, and often practically unavoidable, influence of foreign pollen must afterward be eliminated by means of well directed selection during some of the next generations. Such families are called élite races, and from them every year a branch is taken for the production of the seed needed for culture in the fields or for the trade. Accordingly it must be multiplied in a high degree, but this multiplication must always be accompanied by a continued selection on the basis of external characters as well as of the amount of sugar. One, or at best two, generations without such selection are allowed; but if a breeder should multiply his seed entirely without it, the value would soon sink far beneath the limit required in practice. There are no races rich in sugar which would maintain themselves without such continued help.

Next to the sugar-beets come a number of garden plants in their varieties with double flowers. Ordinarily, such a variety has originated only once, and is in this sense a true elementary species. But the breeder chooses his seeds from the best individuals only, in order to secure a high percentage of beautifully doubled flowers among the progeny. This improvement of the seeds, however, is effective only for the very next generation, and therefore it is necessary to repeat the selection every year. Numerous instances could be given, and it seems that the rule prevails that the selected characters are in a high degree dependent upon the conditions of nourishment; or, in other words, that in reality the selection is only the choice of the best nourished individuals as seed-bearers. Whenever this nourishment, by means of a fuller development of the seeds, is effective through some successive generations, the races are called high-bred, and are liable to decline in a few generations after the subsidence of the selection.

Excellent material for the study of such high-bred races is afforded by some deviations of seedling plants, and especially by tricotylous and syncotylous races. I have cultivated some of these races and found them, in the main, to contain about fifty per cent. of deviating individuals. By means of selection it was easy to bring this standard, in a few years, up to ninety per cent. and more, or down to ten per cent. and less. The selector, however, must not be content with choosing the most perfectly tricotylous or syncotylous seedlings for the continuance of the race. This external mark has only a very secondary value. We have to breed from those individuals whose progeny is the richest in the desired deviation, and therefore to determine this standard for a number of seed-bearers, in order to choose from among them the one with the highest percentage figure. It is a fact well worthy of notice that such breedings succeed almost as easily by insect fecundation as by means of artificially conducted pure self-pollination (*Oenothera hirtella, Antirrhinum majus*), the reason being that the obnoxious effects of foreign pollen are at once eliminated by the selection itself.

Among the most interesting of these cases are the middle races, or those which continually oscillate between two ideal types, without being able to transgress their limits and to change into one of those types. Tricotylous races, for instance, oscillate between pure dicotyly and pure tricotyly; and although the single individuals may apparently show both these types, the race never reaches the one end, to the complete exclusion of the other. In such cases the range of variation is evidently an exceptionally wide one, and therefore it must be easy for selection to encroach upon it. But we should always keep in mind that the basis of selection should never be sought in the externally visible qualities of single individuals, but only in the average amount of these

qualities among their progeny. In other cases the width of variation within the limits of an elementary species is much smaller, and wherever this condition prevails it is often difficult to reach any amount of durable improvement by means of selection. Johannsen has studied such instances, and his results may be considered as one of the best supports of the theory of mutation. For it must be clear to every one that, when selection can bring no improvement at all, it cannot even be supposed to be conducive to the production of new species and varieties. In order to be wholly sure of the purity of his cultures, Johannsen has limited his experiments to such forms as are fertile with their own pollen; but, unfortunately, this condition is far from being the general rule in nature. Moreover, he starts from a single self-pollinated individual, and in this point he follows the principle laid down in my mutation theory and introduced by Nilsson into agricultural practice. To such cultures, derived from single selected mother-plants, he gives the name of "pure lines." His method soon found universal approval, and by this means strongly contributed to the spread of the new ideas. Within these pure lines and in the examples chosen by him, selection does not provoke any real changes. High-bred races do not occur in this field, and so there is also no chance of winning new and constant races by means of them. The significance of this principle seems to me to be a very large one, and to hold good for far longer periods than those of ordinary experiments. We may deduce this from the cultures of Bonnier with the alpine plants. In this case natural selection has been at work during centuries, and in many instances probably since the last of the glaciary periods. But this has been of no avail—at least, not in such a degree that alpine plants would have become purely and exclusively adapted to their environment. For, as is well known, they

have not at all lost the property of accommodating themselves to the conditions of a low country.

Our second proposition was that mutations can be the source of new and constant races which are independent of selection. In discussing this point, we must distinguish between those cases which have been observed only after the mutation took place, and those which have been controlled for several generations in advance. The former we shall call empirical and the latter pedigree mutations. The former group includes those numerous cases of the origin of well observed novelties either in horticulture or in the field; while the other class is concerned with mutations occurring in carefully guarded cultures in an experimental garden, after at least several generations of the old type have been controlled. In the case of empirical mutations we must base our conclusions concerning the forefathers of the new type on the basis of observations made in the moment of its discovery, and often this may give a very convincing degree of probability. In the other case, the ancestors, however, are empirically known. Moreover, it is only these latter cases which afford us the necessary material for a detailed experimental study of the conditions under which the mutation took place.

The oldest and best known example of an empirical mutation is the sudden origin of *Chelidonium laciniatum*. A compilation of a large number of other cases has been given in my mutation theory and a critical and historical review of the instances recorded in horticultural literature has been published by Korshinsky. To these instances Solms-Laubach has added his *Capsella Heegeri*, and Blaringhem his *Capsella Viguieri* and others; and the list of cases is increasing almost yearly. We may therefore state that the fact itself is now beyond all doubt. Instances of pedigree mutations

have been described in my mutation theory, especially in the case of *Linaria vulgaris peloria* and of the double *Chrysanthemum segetum*, or corn-marigold. Referring for the description of these experiments to the source I mentioned, I will point out here the critical and methodological side of the problems involved.

In the case of the peloric toad-flax, the aim of the experiment was to control experimentally the instances of this mutation which had so often been observed in nature; in other words, to watch the occurrence of such a change in a well guarded pedigree culture. The observations made by different authors clearly pointed to a sudden origin without transitions or visible preparing steps. No intermediates had ever been found. My aim, however, was to see the mutation taking place. Evidently, peloric flowers owe their particularity, in a morphological sense, to the loss or to the latency of the symmetrical structure of the flower; but by far the greatest number of instances of empirical mutations refer to such losses, and as yet there is no ground for supposing that progressive changes should behave differently in this respect. In my experiment the first completely peloric individual—*i.e.*, the plant which had all of its flowers, without exception, in this condition—was seen in the fourth generation. It was soon followed by others, and in a sufficient number to show that the mutation occurred in about one per cent. of all the individuals, and was repeated in succeeding generations. Unfortunately, these peloric plants were almost wholly sterile; and I contrived only with difficulty to raise about a hundred individuals from their seed. These, however, repeated the anomaly, although with a few exceptions, due probably to the extraordinarily difficult conditions of the artificial self-pollination of these almost sterile flowers. Intermediate forms did not occur, neither in the number of

peloric flowers per plant nor in that of the spurs per flower. It is hardly necessary to point out that a single experimental mutation of this kind provides a much deeper insight into the phenomena than all the empirical mutations of this species taken together.

In some respects the case of the double corn-marigold is different from this. The starting-point of this experiment was derived from two empirical theses. One of these is the proposition already mentioned, that within pure races selection is the choice of only the best nourished individuals. The other is the increment of chance of the occurrence of mutations caused by a high degree of nutrition. From a combination of these two empirical rules we may derive the belief that in experiments on mutation a most carefully conducted and luxurious culture is to be combined with sharp-eyed selection. Moreover, we may apply a third rule which deals with the sensitive periods in the development of variable qualities. It says that selection chooses especially those individuals which have been best nourished during this sensitive period of the character in question, and from this we may deduce that the chance of new mutations lies mainly in the direction of those characters which we choose for our selection, or of such as are most intimately connected with them.

The point of this discussion should always be kept in mind in the planning of new experiments on mutation, as we shall easily see by applying it to the case before us. It involves the principle that the chance of winning a double variety may be enhanced by selection in the direction of increasing the number of the ray florets in the flower-heads. This augmentation refers to the outer range of florets, while the doubling consists in the change of the florets of the disk into rays. The two phenomena are therefore essentially different, and

in my cultures they were observed to be not connected by transitional or intermediate forms.

By means of very careful selection I succeeded in bringing the average number of ray florets in the flower-heads from the ordinary type of twenty-one (the number of the variety I started from) up to thirty-four; and in doing so the extremes were seen to reach even sixty-six rays per head. After this was reached a change in the disk suddenly made its appearance, and this in one of the seed-bearers chosen for its extremely high number of rays. Next year the seeds of this one plant were sown separately, and at once they gave the expected double race in full display. It seems justifiable to assume that the numerous double varieties of species of the family of the composites have originated in the same way, in the field or in the garden, and in the latter case probably under the influence of unconscious selection.

After the same method I succeeded in producing a twisted race of *Dracocephalum moldavicum* by means of the selection of tricotylous individuals. To this experiment I was led by the description given by Morren of a most beautiful instance of spiral twisting in another species of the same genus. But from these instances we may not conclude that such pedigree experiments will always give the desired result. Thus, for instance, I have tried in vain to win a double petalomanous variety of *Ranunculus bulbosus,* although such a variety from time to time occurs in the field in Holland. Also, I did not succeed in producing a purely four- or five-leaved race of the red clover; nor even a constant seven-leaved form. But it is still possible that the difficulties in finding out the most favorable methods of growing these wild plants are at least partly to be considered as the causes of this lack of success.

Advance in the study of the question of mutation seems

now to depend mainly on the accumulation of numerous pedigree cultures of this kind. It should be possible to repeat the mutations which are known to have occurred in nature or in horticulture, in an experimental way, with either the same or with allied species. The conclusions which are now derived from empirical mutations should be based upon observations in the experimental garden. In working on this principle, not only more exact proofs may be reached, but we should come into possession of the material needed for a more thorough study of mutations and of their internal and external conditions. Here is the starting-point for the long path which must still be explored in trying to produce intentionally chosen novelties; but it does not seem at all impossible to surmount the difficulties, even in this field, and thereby to open new sources of artificial improvement for our crops.

In nature, probably, the production of new forms has taken place sometimes sporadically and sometimes in groups. It is chiefly a paleontological question which of these two processes has had the prevailing part in the evolution of the vegetable and animal kingdoms. Have the main branches of the pedigree been started from among those rich groups of species and varieties which constitute the so-called polymorphic types, or are these latter types only products of the lesser branches? As far as our present knowledge goes, both cases seem to occur. At the present time the polymorphous genera and species, the misty spots of the older systematists, and the groups of explosive changes of Standfuss, are evidently the consequences of such mutation periods. But most of them are already past that stage, and no traces of mutability have been preserved in them. Or, perhaps, this changeability is limited to a few of the numerous forms, and it has as yet not been possible to discern these among

them. On the other hand, it is clear that cases of the simultaneous production of groups of new forms provide a far more suitable material for experimental researches than do sporadic mutations. The former type may include the most divergent kinds of specific changes. It is on the ground of this conception that in the beginning of my experiments I sought a species which would be in such a condition of mutability. I tried more than a hundred species, mostly of wild plants of Holland; cultivated them for several years in my garden, and finally selected one from among them which seemed best suited for my purpose.

This one was the evening primrose of Lamarck, introduced long ago from America into Europe, and which has run wild in different spots. It was the *Oenothera Lamarckiana*. The processes of the mutation of this evening primrose have been observed of late by so many investigators that no traces of doubt concerning their reality any longer remain. It is true that the whole case is still an isolated one, but it is evident that a further search will sooner or later lead to the discovery of analogous instances. On the other hand, the question of the significance of these observations as typical for the theory of evolution, as well as that concerning the true nature of the mutations themselves, is a subject of much discussion. It is a struggle for and against the *Oenotheras* and their evolutionary value; but this struggle is concerned with the mutations themselves as they occur in our experiments, and not—or at least not directly—with that primary condition of them which I have called the premutations. This internal tendency to mutation is proved by the fact that the same new forms may arise yearly from the main stem of the cultures, and often in a relatively large number of individuals. Generation after generation, the same mutations are repeated, and this re-

veals to us an hereditary condition of the germ-plasm which must have remained unchanged during all the twenty-five years of my experiments and evidently during a much longer period of time. In what way, and when, these internal predispositions have been acquired, the visible consequences of which are the mutations, is a wholly different question, which has until now hardly offered itself to experimental treatment.

This question of the premutation, or of the internal preparation of the mutability, is most intimately connected with that of the duration of the whole period of mutations. In this respect the first proofs have referred to the introduction of the *Oenothera Lamarckiana* into Europe, and have shown that it must have been already in a mutable condition at that time, or about sixty years ago. This conclusion was derived from the fact that the different strains, issued from that introduction shortly after it had taken place, all showed the same phenomena of producing new forms.

Later observations, and a better appreciation of some older ones on the ground of them, then led to the view that the mutability must in this case be older than the species itself, and have developed gradually together with the specific differentiation within the group of the *Onagras* to which *O. Lamarckiana* belongs.

The main support of this view is the discovery of the fact that the European type of *O. biennis* has the same property of producing dwarfs which is so prominent in *O. Lamarckiana*. This has of late been observed by Stomps in his cultures of *O. biennis cruciata,* and it has occurred also in my experimental garden. The common view takes this *O. biennis* to be one of the forefathers of *O. Lamarckiana,* and therefore present indications assume that the property of producing dwarfs has been inherited by *O. Lamarckiana*

from such ancestors. This view is supported by that curious quality of the dwarfs of being sensitive in a high degree to the attacks of some kinds of bacteria of the soil; this sensitiveness and the changes in the structure which it produces being exactly the same in both of these kinds of dwarfs. I shall have to refer to this disease later on.

Elsewhere, also, among the nearest allies of the evening primrose of Lamarck, phenomena of mutability may be seen to occur. *Oenothera cruciata* has given in my cultures from their very beginning three types, which differed from each other especially in the form of the flower-buds; it has shown the same elementary forms in the cultures of MacDougal. This author studied also the *Oenothera grandiflora* from Alabama, and the origin of new derivative forms from it, and stated that analogous deviating types are also met with in its original station near Tensaw. Moreover, the cultures of Davis have given evidence of a wide range of subordinate forms within the type of *Oenothera grandiflora*. In the neighborhood of Courtney, Missouri, I observed, among numerous specimens of the ordinary American type of *O. biennis*, a deviating individual with narrow leaves. Analogous mutations have arisen from the seed collected in that station from normal plants and sown in my garden. One among them proved especially interesting in being of lower stature and of a more slender structure than its very stout ancestor.

According to some stray observations, mutability is not at all limited to these examples, but occurs in different allied species also. From all of these facts we may safely conclude that mutability is a wide-spread phenomenon in the group of the *Onagras*, and that it has not originated with the origin of *O. Lamarckiana*. This weighty conclusion has of late found an unexpected support in the discovery of Stomps that

the European *O. biennis* is liable to the production not only of dwarfs, but also to that of the main progressive type among my mutants, the *gigas*. As a matter of fact, it has not as yet been observed to throw off *gigas*-plants as such. But it has given a half-*gigas*—*Oenothera biennis semigigas*—characterized by intermediate marks between real *gigas* and ordinary *O. biennis*, and especially by having in its nuclei in the one half the fourteen chromosomes of the former, and in the other, the seven of the latter. In other words, it has twenty-one chromosomes, being in this respect wholly analogous to the triploid mutants of *O. Lamarckiana* so fully and ably described of late by Miss Anne M. Lutz.[1]

Returning to our general discussion, it is clear that the other species are only mutating in a lesser degree than *O. Lamarckiana*, and from this fact we conclude that the extent of this property must have increased gradually during the phyletic evolution of the group. Or, in other words, the present mutability of *Oenothera Lamarckiana* is built up by a number of factors, more than one of which have evidently originated already with its ancestors. It goes without saying that the single steps of this process must themselves be regarded, on the basis of our theory, as constituting each of them a special mutation.

By means of the facts which I have just described, many objections made by different authors may easily be surmounted. The question whether *O. Lamarckiana* has still one or more wild stations is no longer of interest, since most of the other mutating species are recognized to be good wild types. This is especially the case with *O. grandiflora*. From my discovery that *O. Lamarckiana* produces twin hybrids, *O.*

[1] Since the reading of this address numerous cases of mutability in allied species of *Oenothera* have been discovered by H. H. Bartlett. (Note of 1915.)

læta and *O. velutina,* when it is crossed with certain of the older species, some authors have drawn the conclusion of a hybrid nature. But Davis has shown that *O. grandiflora* produces the same twins in analogous crosses; and in order to explain this fact by a hybrid condition the adversaries would either have to assume such a condition separately for the two species, or suppose a hybrid origin for their common ancestors. Both suppositions seem to lie far beyond the realm of credible scientific hypotheses.

Other grounds for assuming a hybrid nature for *O. Lamarckiana* must disappear before the same group of facts. As a matter of fact, it is generally conceded that in polymorphous groups of species some forms may have been the result of crosses between others. This opinion was held by Linnæus, and for the cereals it is evidently true, as is proved by the researches of Nilsson and others. Any one who has studied the species of *Oenothera* in botanic gardens must have been struck by the fact that they are very rich in constant hybrids. But all such observations are far from containing even a single trace of proof in favor of the assertion that mutations should be a consequence of previous crosses.

Some authors deal with the struggle against the *Oenotheras* in a rather inconsiderate way, especially among those who enjoy any argument pleading for "the possibility of the Mutation Theory being based on false premises." As an example, I may give the observation of Boulenger.[1] He found a station for *Oenothera Lamarckiana* in Bretagne, not far from La Garde St. Cast (Côtes du Nord). Here it had started from the neighborhood of the hotel and spread

[1] G. A. Boulenger, in "Journal of Botany," October, 1907.

through the surrounding dunes during several years. He found that it showed a high degree of variability, especially in the direction of the characters of the European *O. biennis*, a long line of transitions and intermediate steps being clearly made out. He tried to recognize among them the types of my mutants, but they proved to be wholly of another nature. Neither did he succeed in determining a limit which would separate two groups, the one belonging to *O. Lamarckiana* and the other to *O. biennis*. From these facts he concluded that *O. Lamarckiana* may locally revert to some ancestral form which would have been very similar to, if not identical with, the *O. biennis*. Every botanist would of course have come to a different conclusion and assumed that *O. biennis* had already been present on that spot, being a common inhabitant of the dunes, and that it had readily crossed with the introduced *Lamarckiana* so as to produce quite a number of intermediates of hybrid origin. And even the pointing out of this possibility would have destroyed the whole basis on which Boulenger thought it safe to attack the new theory.

Moreover, it is rather easy to prove that the transitions of Boulenger must really have been such hybrids. In crossing the species in question, we come upon three clearly distinct types, two of which have been already dealt with. These are *Oenothera hybrida læta* and *velutina*. They result from the cross *O. biennis* × *Lamarckiana* and constitute its twin hybrids. The former has broader and flatter, the other narrow and rolled leaves; but aside from this mark, they differ in almost all their organs and qualities. The third hybrid results from the reciprocal cross, *O. Lamarckiana* × *biennis;* its characters are very similar to those of *O. biennis*, from which in some specimens it is often hardly discernible. To determine the limits of these five

types in a mixed group of plants may seem a difficult task even to an experienced eye; in any case, Boulenger failed to recognize them. *O. biennis* is one of the more common species in many parts of the dunes of Holland, where it is known to have grown already at the time of Linnæus. Not rarely *O. Lamarckiana* is sown on the same spots, being a favorite food for birds; in such cases the hybrids will arise by the natural processes of fecundation by insects. This of course also happens from time to time in the dunes of Holland, and I have observed it in an unusually broad area for the *Oenotheras* in the neighborhood of Zandvoort, where I studied it with special care in 1905 and 1910. In the spring of 1906 I sowed seeds of this motley group in my experiment garden; and in 1911 I introduced a set of rosettes and got them to flower. The hybrid types were easily recognized, although, on account of their transgressive variability, they seemed to constitute continuous lines of variation in many characters. In the dunes these differences are less evident than in the experiment garden, on account of the very different life conditions. In groups, however, it is easy to ascertain the types, but from such a station I would never use the seeds for any experiments in mutability. Every single individual must always be regarded with some doubt as to the purity of its origin.

In England, also, the two species often grow together. Charles Bailey has described such a station from the neighborhood of St. Anne's on the Sea, near Liverpool. Therefore I asked one of my friends to visit this station for me, and he informed me that in some of the valleys *O. Lamarckiana* was seen to be pure, while in others it was mixed with *O. biennis* and the hybrids.

In order to give a general review of the single mutants

which have arisen from the *Oenothera Lamarckiana,* we may bring them into certain groups:

A. Progressive mutations: *O. gigas.*
B. Retrogressive and degressive mutations:
   1. Mendel cases: *O. brevistylis.*
   2. Half Mendel cases: *O. nanella, O. rubrinervis.*
   3. Not Mendelizing mutants: *O. lata, O. scintillans, O. oblonga, O. lævifolia.*

Besides these, there is a long list of instances which have not as yet been studied by means of crosses, as, for example, *O. albida, O. elliptica, O. leptocarpa, O. semilata, O. spathulata, O. sublinearis, O. subovata,* and many others to which no names have been given on account of their sterility or of their excessive feebleness. Mutations have also been won by other investigators; among them the *O. rubricalyx* of Gates, the *O. ammophila* of Abromeit, and the *O. blanda* of Schouten must here be mentioned. During the last ten years I have not tried to increase the number of the mutants; but notwithstanding this, I have secured some interesting novelties. The fact that in this whole group only one species is of a progressive nature, while the large majority are either degressive or retrogressive, has had stress laid upon it by some authors as a strong objection, but it is just what we should expect on the ground of our knowledge of other polymorphous groups.

As is well known, a certain group of authors assert that all hybrids and all characters must necessarily follow the rules of Mendel. A criticism of this evidently one-sided conception would take me too far from my real subject. At the present moment I will therefore limit myself to the contention that conclusions drawn from immutable plants are

not *a priori* applicable to those which are in a condition of mutability. On the contrary, these latter behave in many respects differently, and it is only with them that I shall have to deal here.

Let us first look at the progressive mutations. According to our theoretical conceptions, they owe their origin to the appearance of a new kind of hereditary unit, or pangens, which must have been split off by some one of the previously existing units. This latter can be in a condition of premutability, and thereby able to repeat the same mutation from time to time. Whether this premutation is caused by its own condition, or is due to the influence of neighboring pangens, is a question which is not now in need of an answer. It is only a few progressive mutations that are of a phyletic nature—*i e.,* made for contributing to the building up of the pedigree of the whole system; by far the greatest number must, of course, be limited to ordinary specific differences.

In the foreground of our discussion of *Oenothera gigas* we may put the fact that it possesses, in its nuclei, a double number of chromosomes in comparison with the species from which it arose and with almost all of its other derivatives. *O. gigas* has twenty-eight instead of fourteen in the vegetative cells, or fourteen instead of seven in the generative elements. This important fact was discovered in 1907 by Miss Anne M. Lutz and corroborated shortly afterward by Gates, and later on by my pupils Geerts and Stomps. It has brought the new species to the foreground of cytological interest. Similar duplications of the set of chromosomes constitute important specific marks in other groups of plants; and in no single case are there arguments in favor of regarding it as a retrogressive change.

For the origin of a progressive mutant, in this case of a plant with a double number of chromosomes, it is obviously

necessary that two mutated sexual cells should combine, as was first pointed out by Stomps. This condition is not the same for retrogressive and digressive mutations, as we shall see later on. It is true that Gates has expressed a different opinion and asserted that the duplication takes place only after fecundation, not being a real mutation, but more in the nature of an accident.[1] This, however, would bring the whole phenomenon into the class of acquired characters which are now generally considered as not hereditary. From this point of view, the conception is in evident contradiction to the facts, since the *gigas* has continued its existence already during several generations. In this connection I may point to the double-nucleated cells of *Spirogyra* in the experiments of Gerassimow, which retain this special mark during all the vegetative divisions, but lose it as soon as fecundation comes into play. Moreover, the facts since discovered fully disprove the view of Gates.

Oenothera gigas has been seen with sufficient evidence to arise only once in my cultures. This was in 1895, from pure seeds of 1891. It is only of this race that the chromosomes have been counted. In the beginning I believed that I saw it in other years also; but at that time I did not know the characters of the hybrid between it and *Lamarckiana*. Looking back to those cases, it now seems to me that they were only half mutants, produced by the conjugation of a mutated sexual cell with a normal one. In this case they should have had twenty-one chromosomes in their nuclei, but they have not been studied in this respect and did not bear any seed. Such supposed half mutants have since been seen to arise more than once, because it was now known that there are reasons for expecting them and looking for them. For one of these the chromosomes have been counted by Stomps,

[1] R. R. Gates, "Archiv für Zellforschung," 3 Bd., 4 Heft, 1909, p. 549.

who found the expected number of twenty-one. This observation proves, first, that the duplication takes place before fecundation, and secondly, that the mutation is not so rare in the germ-cells themselves that we should be justified in considering it as an accident. By means of a careful and extensive study, Miss Lutz has discovered the same fact. In her cultures she observed ten half-*gigas* mutants arising from *O. Lamarckiana,* and in counting the number of chromosomes for all of them, she found it, without exception, to be twenty-one.[1]

It may here be mentioned that Heribert Nilsson discovered in 1907, in Sweden, a mutation of *O. Lamarckiana* in *gigas*.[2] It gave an hereditary race, but nothing has been published in regard to the nuclei. Another important fact is the discovery of Geerts, who met once, in his cytological studies of *O. Lamarckiana,* with a mother-cell of an embryo sac which showed in its division twenty-eight instead of fourteen chromosomes. Controlling these observations, I have accurately compared my half mutants with the artificial hybrids between *O. gigas* and *O. Lamarckiana,* and convinced myself of their external identity in all respects.

On the basis of these experiences it is possible to calculate the mutation coefficient for *O. gigas*. Most suitable for this purpose are crosses of *O. Lamarckiana* with such species as produce only, or almost only, yellow, very weak and soon dying hybrid germs. This is the case when *O. Lamarckiana* is pollinated with the pollen of *O. cruciata, O. muricata* or *O. Millersi* (*nov. sp.*). We have only to count the germinating seeds and to cultivate the few green ones among them. As in *Lamarckiana,* all of its derivatives give such yellow seedlings, the only exception being that of *O. gigas.*

[1] Miss Anne M. Lutz, "Triploid mutants in *Oenothera,*" *Biol. Centralbl.,* Bd. 32, July, 1912, p. 384.

[2] "Bot. Not.," 1909, pp. 97–99.

Those sexual cells which have been mutated into this form will therefore produce green seedlings, which it will then be easy to isolate from the rest. In growing up they may soon be recognized by their much stouter stature, and for this reason Stomps has proposed to call them *Hero*. In counting their chromosomes, he found them to be twenty-one in each nucleus, this number being the sum of seven chromosomes derived from the father (*O. cruciata,* etc.) and of fourteen derived from the mutated egg. This, of course, is a sufficient proof; but the *Hero* plants may afterward be easily recognized as such by their stout flower-buds and other characteristics.

Among fifteen thousand yellow seedlings, forty-five examples of *Hero* were counted, giving a percentage of 0.3. If now we assume that the mutations are as numerous in the male sexual cells, the chance of their meeting together and thereby producing a full *gigas* will obviously be equal to the quadrate of this number, or 0.0009,—say about 0.001%. In my mutation theory I had provisionally conjectured this number to be 0.01%.

The size of the cells and of some of the organs of *O. gigas* has increased in consequence of this doubling of the chromosome number and in accordance with the laws discovered by Boveri and Marchal. This fact was first pointed out by Gates. This author extended his conclusions to all the differences between *O. gigas* and *O. Lamarckiana;* but this has been shown by Stomps to be unjustifiable. Neither the biennial habit, nor the large seeds in the small capsules, nor the adhesion of the axillary buds to the stem above the leaf can be explained in this way. The same is the case with other marks. Here I might, however, lay stress on two points which can hardly be considered as consequences of a double set of chromosomes, but which have of old been con-

sidered as true specific characteristics as opposed to mere varietal marks. I am thinking of the strongly diminished fertility of almost all the crosses and hybrids of *O. gigas;* and, in the second place, of the fact that the hybrids are intermediates between their parents and constant as such in their progeny, whenever they have any.

O. Lamarckiana, as a rule, gives a normal harvest of seeds, after being crossed with allied species, amounting to about 0.3 cc. per capsule. *O. gigas,* however, does not produce after the same crosses more than 0.01 to 0.02 cc. of seeds per capsule; and if sometimes the harvest is found to be larger, the seeds are, as a rule, not capable of germinating, although apparently of good structure. Often it is very difficult to win hybrid seeds at all; as, for instance, in the crosses with the European and the American species of *O. biennis* with *O. strigosa,* with *O. Hookeri* and even with *O. Lamarckiana* and the larger number of its derivatives. Moreover, the hybrids, if once produced, prove afterward to be almost, or wholly, sterile after self-fecundation, and the second generation often embraces only a very few individuals. Reciprocal hybrids are identical, provided the nature of the other parent permits it, and the externally visible qualities are apparently just the mean between the two parents.

On the ground of all these facts I take it for granted that *O. gigas* is a good species, arisen in a progressive way from its parent, although distinguished from this by only a single unit character. In all these respects it behaves differently from all the other mutants.

We now come to a discussion of *O. brevistylis.* It is distinguished from its parent form mainly by the partial loss of the epigynous condition of the flowers. Besides this, it is the only one among all the derivatives of *O. Lamarckiana*

that exactly follows the law of Mendel; and this in its crosses with the parental species as well as with its derivatives and with the older species. In some crosses it may be seen to split into the twin hybrids *læta* and *velutina* in the same manner as its ancestor, but then both of the twins will split in respect to the length of the style, according to Mendel's formulæ.

Of course the same splitting must occur in the field where it grows together with *O. Lamarckiana.* As a matter of fact, it is not possible to distinguish the hybrids from that species on first inspection; but in bringing numbers of rosettes of root-leaves to the garden from time to time a single plant may be met with, the progeny of which contains the short-styled individuals in the number required by Mendel's rule. Such a case I happened to find in my cultures in 1905. From this we may infer that the short-styled specimens (which almost every year are seen to grow in the field) may be offspring of such hybrids, and thus their existence is far from proving the presence of another source, such as a direct mutation from *O. Lamarckiana.* Moreover, it seems that this mutability is wholly exhausted, since the mutation has never repeated itself in my cultures.

If we try to penetrate into the mechanism of the original mutation to which my race owes its existence, we find that obviously the change of a single sexual cell must be considered as sufficient. Its fecundation by a normal cell will give rise to a hybrid, from the seeds of which the pure type of *O. brevistylis* will come into existence. The hybrid could not be recognized in the field, but the short-styled individuals at once strike the eye by wholly different qualities. These themselves produce no seed at all, or hardly any; but in fecundating the surrounding *Lamarckianas* they will give rise to hybrids, from which the pure type may once more be

produced. There can be no doubt that it is in this way that the *O. brevistylis* has kept its place in the field during the almost twenty years of my observations.

We may now turn our attention to those mutants which follow the laws of Mendel only half-way. They do not comply with these rules in their crosses with the parental form, nor with the majority of its derivatives. But in those crosses with other species which split them into twins the rule is that one of the twins follows these formulæ while the other does not. To this group we may bring *O. nanella* and *O. rubrinervis.*

Before detailing the results of the crosses of these two new species, I must call your attention to one of the most curious objections that have been made in the struggle of some authors against the *Oenotheras.* I mean the contention that the dwarfs should not be a pure hereditary race, but only diseased individuals of the ordinary *Lamarckiana.* Of course nobody who ever saw the two cultures side by side can hold such an opinion, since transitions are always absent. The dwarfs do not attain half the height of the parental form, and are almost all of the same stature. This is purely reproduced from seed, without exceptions or deviations. The contention I mentioned starts from a discovery made by Zeylstra. He observed a curious type of bacterium within the cells of the dwarfs, and showed that the presence of this parasite is the cause of some of their characters, formerly held for specific marks: thus, for instance, the broadened bases of the leaves, the brittleness of their stalks, the frequent curvature of the flower-buds, the failure of the style in some flowers, and others. But in opposition to these minor points, the stature of the dwarfs is neither caused nor sensibly affected by the parasite. This may be proved in an easy way by cultivating the dwarfs on a soil rich in phosphate

of lime and relatively poor in nitrogenous manure. Under such conditions the phenomena of the disease are seen to disappear completely, or almost so.[1] The leaves become narrow and stalked, the internodes longer, the brittleness is lost, the flower-buds are straight, and the flowers open in a normal way. Often one or the other leaf still shows signs of the disease, and so betrays the presence of bacteria in the cells. But the main point is that the stature remains the same; the dwarfs are still dwarfs, even when they are in the best of health. They constitute a distinct mutation, which, however, is distinguished from the parental type in two points—viz., the stature and the sensitiveness to certain kinds of bacteria of the soil. As already stated, the same holds good for the dwarfs of the *Oenothera biennis*.

From the crosses of *O. nanella* and *O. rubrinervis* with some of the older species the same twins arise as from the analogous crosses of *O. Lamarckiana* itself. They are the *læta* and *velutina,* of which I have already spoken more than once. In such cases dwarfs are lacking in the first generation; and from this we should expect a splitting in the second, according to Mendel's law. As a matter of fact, this splitting does occur, but only among the progeny of one of the twins. The other gives a constant race without dwarfs. And since the twins are usually produced in about equal numbers, it is one half of the progeny which complies with Mendel's law. Hence the name of "half-Mendel hybrids." As a rule, it is the *velutina* which produces the dwarfs, while the *læta* remains constant.[2]

It is evident that such splittings cannot occur in the field

[1] "Science," N. S., Vol. XXXV, No. 906, pp. 753–754, May, 1912.

[2] For more details see my book, "Gruppenweise Artbildung," which is soon to be published. A modification of the process of splitting may be introduced into these experiments by the use of heterogamous species, as, for instance, *O. muricata*. See also "Ber. d. d. bot. Ges.," Bd. XXVI a. 1908, p. 667.

on spots where the *Lamarckiana* is free from the admixture of other species. In such cases we are concerned only with the crosses of the derivatives among themselves and with the parent type. From these crosses only the parental types are repeated, and, as a rule, to the exclusion of others. Fecundating themselves, they will prove constant. From these experimentally ascertained facts we may conclude as to what must happen in the field. A mutation may keep its hold there in three different ways: first, by means of self-fecundation; secondly, by means of intercrossing with the parental species; and thirdly, by being produced anew, from time to time, from the main stock. To which of the three processes a given individual owes its origin can of course not be seen in the field; and so there is almost never a direct proof of mutations occurring there, except in those cases where the mutants succumb in the struggle for life before opening their flowers. And this is not at all rare under the adverse conditions of the field at Hilversum.

The results of our crosses show that in many cases the coöperation of two mutated sexual cells is not a necessary condition for a mutation to be produced. It is often quite sufficient that the mutated cell be fecundated by an ordinary one. If this does not occur too rarely—as a rule, in one half of the instances—the mutation will be lost; while in the other half it will dominate and develop its qualities in the new individual. For this is the rule governing artificial crosses. In those cases where it is lost, the new individuals will be identical externally with the ordinary *Lamarckiana;* but it might be possible that such individuals should prove to possess a greater liability for mutating than do others. This point, however, has not as yet been investigated. It might be suggested that it is in just this way that mutability is maintained in the field; but the results of some artificial

crosses do not plead in favor of this opinion, since the *Lamarckiana* individuals produced from such crosses do not show any increase in their mutability.

The facts which we have now described could be used as a starting-point for answering the question concerning the nature of the process of premutation, or of the initial change which induces the condition of mutability. In doing so we should have to assume that originally some mutation had occurred in a sexual cell and that from the copulation of this with a normal plant no mutant, but a seemingly ordinary *Lamarckiana,* had arisen. Then we might assume that this copulation had induced a mutable condition, which must be supposed to have become hereditary and to have given rise to an hereditary race. If such a change had taken place in the lapse of time, first for the mutability into *O. nanella,* it could have been followed by a similar change for *O. rubrinervis,* then for *O. lata* and *O. scintillans,* and so on for the whole range of known and as yet unknown mutants.

But such speculations hardly throw any light on the real nature of the processes of premutation, nor on that of the premutated condition, nor on the power of mutating derived from it. I have only mentioned them in order to show that the hypothesis of Bateson concerning this process is as superfluous as it is erroneous. This author contended (1902) that mutability might be a result of crosses with other preexisting species, which would have been in the possession of the qualities afterward displayed by the mutants. In opposition to this supposition, many authors, and among them MacDougal, have pointed out that the species required for the justification of this view do not, as a matter of fact, occur. And if we review the qualities of the different new types produced by *O. Lamarckiana* as mutants, the number of which amounts to more than twenty, we shall soon be

convinced that the large majority of them are too weak in some respect or another to be able to exist in nature. They would have been crowded out almost as soon as they had arisen. The only way of escaping this difficulty would be to assume that those hypothetical species had possessed the desired qualities only in a latent condition. But this supposition would, in another respect, be contrary to the views of Bateson. Under these circumstances, I think it must be conceded to be a more simple supposition to leave out the conception of a long row of hypothetical ancestors, and only to assume a succession of those premutations the consequences of which may yearly be observed in the mutations they produce.

But still one could be inclined to consider the premutation as a consequence of the cross of a mutated sexual cell with an unchanged one. In order to produce the desired result, such crosses would have to occur more than once, since only half of them may be expected to produce mutable *Lamarckiana* plants; and the reason for such repetitions would then remain an obscure point in the discussion. But, as already stated, all these considerations do not bring us nearer to an understanding of the phenomena. Therefore I will limit myself to the citing of the extensive criticism of Blaringhem (*l. c.*, pp. 173–186), and to pointing out the most important fact described by Geerts—namely, that the rudimentary condition of the pollen grain, which plays so large a part in those hypotheses which ascribe a hybrid nature to *O. Lamarckiana*, is not at all characteristic of this species and its nearest allies, but is seen to occur throughout almost the whole family of the *Onagraceæ*. It is evident from this that it cannot be considered as proof of a hybrid nature of any species of that family.

Moreover, I might once more lay stress on the assertion

that it is not permissible to apply conclusions drawn from immutable plants in an explication of the conditions of mutable ones. Such a process would be justifiable only in case it were experimentally shown to be possible to change the ordinary immutable types into the rare and so much desired mutable forms, only by means of artificial crosses. But as yet all experience is contrary to such a conclusion.

The last group we have to consider embraces those mutants which in no respect comply with the laws of Mendel. It may be sufficient to deal with them only very briefly here. Their first generation, after being crossed with the parental species, is as a rule a twofold one which only repeats both of the parental forms. In the case of *O. lævifolia* and *O. oblonga* these types are at once constant, while in that of *O. lata* and *O. scintillans,* which are inconstant types themselves, the form which externally corresponds to them does so in respect to its constancy also. Only the *Lamarckiana* individuals sprung from these crosses remain constant when self-fertilized.

It is clear that the discussion given above for the appearance of individuals deviating in the field, as well as that for the process of premutation, is directly applicable to this case too. It would be useless to repeat them. But the results of my crosses indicate a long range of possibilities, which it is as yet hardly possible to combine into a simple and clear scheme. They have only one feature in common, and this is the total absence of splittings conforming to Mendelian laws.

Of course it is not possible to review here all the objections made against the significance of the *Oenotheras* for the mutation principle. The theory does not stand or fall with the validity of a single example. It has been derived from general considerations, and is supported by a critical review of numerous facts taken from the most diverse fields of

natural science. It has found rapid recognition in almost all circles of biological inquiry, and has caused the principle of pangenesis, laid down by Darwin, to become the starting-point for the theory of heredity.[1] It is true that, as I have already pointed out in the introduction to my mutation theory (Vol. I, p. v), work on the basis of this principle is far more easy in the domain of hybridology than in that of pure heredity. The development of the experimental studies within the last ten or twelve years has fully justified this assertion. Hybridology, or at least that part of this science which deals with Mendelism, has developed to a bright and flourishing science, while only a few investigators have devoted their work to the study of pure descent. In the next few years the main interest will probably turn to the production of new species within pure and well-guarded strains,[2] partly in order to get extensive proofs of the fact itself, and partly to find their explanation. Along these lines scientific research is gradually approaching its highest scope: the artificial production of new forms of life—forms planned beforehand.

HUGO DE VRIES.

[1] See C. Stuart Gager, "Intracellular Pangenesis," English edition (Chicago, The Open Court), 1911.

[2] See L. Blaringhem, "Transformations brusques," *l. c.*

THE ELECTRON AS AN ELEMENT

COMPOUNDS OF ELECTRONS

THE DISRUPTION OF THE SO-CALLED ELEMENTS[1]

LECTURE I

THE ELECTRON AS AN ELEMENT

THE independent existence of the electron is now conclusively demonstrated; in my opinion, it is, next to the first and second laws of energy, the most far-reaching discovery which has yet been made, both in its application to the elucidating of our former views concerning matter and its nature, and to our control over what are popularly termed "the forces of nature."

Although progress in human thought has usually been achieved from the practical standpoint, still, after a sufficient number of observations have been made, a consistent theory, which permits of the knitting together of such isolated parts into a complete whole, suggests the trend of further research, and renders easy what previously was justly regarded as difficult. It is thus with the idea of the electron as an entity. Once it has been realized that the part played by the electron is all-pervading; that it enters as an element into the constitution of chemical compounds; that when they undergo

[1] Three lectures delivered at the inauguration of the Rice Institute, by Sir William Ramsay, K.C.B., F.R.S., Professor of Chemistry in the University of London.

change, that change is brought about by a shifting of electrons from one form of combination to another; when we realize that a current of electricity flowing along a wire is merely the passage of almost infinitely numerous electrons from place to place, and the formation and decomposition of temporary compounds; when we can clearly conceive that the starting and stopping of such a current of electrons cause ethereal waves, themselves capable of starting or stopping similar currents of electrons in wires parallel to the first; when we realize that by the expenditure of energy such streams of electrons can be set in motion and can be stopped,—then we have acquired knowledge which will enable us to contrive machines better than those which we already possess, whereby the direction of motion of electrons can be controlled.

The fact that electrons cannot be seen need now prove no stumbling-block. For men were for long unable to realize that invisible gases could be put to use. The wind was by our forerunners regarded as semi-spiritual; a ghost and a gust were akin; and I find it difficult to convince my non-scientific, and even some of my scientific, friends that it is much easier to work with and to manipulate gases than liquids or solids. And now gases, in the form of compressed air, compressed steam, or compressed products of explosion, are our chief agents for conveying energy from place to place; they are, electrons excepted, the means by which almost all our energy is transmitted. They have the advantage of being easily moved; of being elastic; and of being conveyed rapidly from place to place without loss. Indeed, if it were necessary to characterize the past century by a single expression, the "age of compressed gases" might be aptly chosen.

The story of the measurement of the mass of an electron has often been told. The "kathode rays" were discovered by Lenard to be able to pass through a thin sheet of alu-

minium; and after their passage they were found to be able to penetrate the atmosphere for some distance, although they were somewhat rapidly dispersed; in fact, the dispersion, with the loss of their activity, has been likened to the passage of light through water to which a few drops of milk have been added. Crookes's previous researches had proved that kathode rays can be concentrated to a point from an aluminium kathode, shaped like a parabolic mirror; that they produce great rise of temperature at their focus; that their impact can impart rotatory motion to a paddle-wheel on the blades of which they impinge; and that they have the property of causing phosphorescence in various objects—many minerals, for example, glowing with marvelously brilliant colors. They are unable to penetrate thick objects; hence a metal cross or other object can be made to cast a kathode shadow when placed in their path, and the shadow can be well seen on the side of the glass vessel in which the rays are generated; the glass phosphoresces with a beautiful green or blue color, except where it receives the shadow of the metal cross.

Crookes also showed that two such streams of electrodes, each arising from its own kathode, repel each other; for if the kathodes were parallel, the streams were not parallel, but divergent. On the other hand, streams of kathode particles, passing in opposite directions, attract each other.

Goldschmidt, many years ago, had noticed that the streams of kathode rays can be deflected by a magnet; and it was this property of the rays, taken with that of their being attracted by a positive and repelled by a negative electric field, which led to the possibility of measuring the ratio of the charge which they carry to the mass of the electron.

Knowing this ratio, it follows that if the magnitude of the charge be known, the mass of the electron will then be deter-

mined. Now, accurate measurements show that this ratio involves one of two alternative suppositions: either that the negative charge is 1830 times the positive charge carried by one atom of hydrogen in the ionic state, or that the mass of the particle is only $\frac{1}{1830}$ of that of an atom of hydrogen. It appeared improbable that the first supposition should be correct; and the matter has been decided without a shadow of doubt from experiments made by Mr. C. T. R. Wilson. A property of ions in a gas is to cause the condensation of supersaturated water-vapor to droplets. The number of such droplets can be counted; the velocity of their fall can be measured. This affords a means of determining the diameter of each droplet, and from that the volume of a droplet can be deduced; and as the total quantity of electricity carried down by the precipitated liquid can be easily measured, the charge on each particle can be estimated. It is that which may be attached to one, two or more electrons; for the ion of a gas may be attached to electrons, and each ion corresponds to one water droplet. Wilson's experiments, as well as the beautiful experiments of Milliken, agree in the conclusion that the electric value of a unit charge, or electron, is 4.78×10^{-10} electrostatic units; and it follows from this that the mass of an electron is $\frac{1}{1830}$ of that of an atom of hydrogen.

It is possible now to go further and to determine the actual mass of an electron. Experiments by M. Perrin on what may be termed visible molecules—namely, particles of gamboge in an aqueous emulsion- have enabled him to deduce with great accuracy the mass of an atom of hydrogen; it is 1.63×10^{-24} gram. Dividing by 1830, the mass of an electron is found; it is 0.8×10^{-27} gram.

Let me interpose here the remark that the method of determining the "atomic weight" of an electron does not differ in principle from the usual method of determining

atomic weights. The usual method is to ascertain the weight of the element in question which will combine with a known weight of some standard element the ratio of whose atomic weight to that of oxygen is known. This ratio is generally determined by the balance, and the result gives the equivalent of the element of which the atomic weight is required. With the electron the process is similar, except in the method of weighing; the "weight" is determined electrically. Indeed, the use of the word "weight" is not strictly permissible, for the attraction of the earth does not come into play; electric forces replace it. But there is now no doubt that the atomic mass of an electron is $1/1830$ of that of hydrogen. It is also certain that what is termed an electric current consists of a stream of such electric particles in motion; and that a negative electric charge consists in the surface of the negatively electrified object being covered with a film of such particles.

We see, therefore, that we have now to do with an element of known atomic weight which has been isolated from its compounds and is thus accessible in the free state. It may be pointed out here that this is not the first time that the existence of elements has been inferred before their isolation in a state of freedom. To quote a familiar instance, fluorine was defined as an element by Davy eighty years before Moissan prepared it by electrolysis of hydrogen fluoride, rendered a conductor by the presence of dissolved salts. The fact of the general resemblance of its compounds to those of the other halogens made the inference legitimate. But the electron possesses properties so remarkable that there is little wonder that its elementary nature was overlooked.

The first suggestion, which, nevertheless, fell short of the truth, was made in 1887 by Helmholtz in his Faraday lecture, when, having indicated that according to Faraday's law

each atom of an element, liberated on electrolysis, is associated with one or more units of positive or negative electric charge, he pointed out that the legitimate conclusion to be drawn was that each liberated elementary atom is associated with one or more positive or negative units of electricity, to which the term "electric atom" might legitimately be attached. It has only been slowly realized that a negative charge is due to the presence of atoms of electricity, or negative electrons, and that a positive charge is due to their absence. We are reminded by this of the long-exploded doctrine of phlogiston, the demolition of which by Lavoisier revolutionized the science of chemistry and gave it a fresh start. In it the absence of oxygen corresponded with the presence of phlogiston, a wholly imaginary conception; just as a positive charge was tacitly assumed to be the addition of positive electricity to matter, while a negative charge corresponded to the association of matter with negative electricity. It is as if the upholders of the phlogistic theory, having been convinced against their will that combustion implied combination with oxygen, had at the same time maintained that during such combination phlogiston is lost. Indeed, Scheele's ingenuity made him devise a somewhat similar hypothesis when he was confronted by the experimental fact that oxygen is produced by heating "mercurius precipitatus per se" in a retort. His explanation was that the heat which entered the retort, being composed of phlogiston plus fire-air, was decomposed by the calx of mercury; the calx, combined with the phlogiston, producing mercury, while the fire-air, or oxygen, the other component of "heat," escaped and could be collected. The reasoning is perfect as long as the use of a balance is excluded; and, as with the electron, it was only by careful weighing that the substantiality of oxygen could be demonstrated.

Similarly, it is now time to reject the old hypothesis that there are two kinds of electric fluid—one positive, one negative; the evidence is overwhelmingly in favor of the theory that electricity consists of an assemblage of electrons, or particles of negative electricity, and that compounds of electrons change their nature when the electrons are removed, just as mercuric oxide acquires the properties of a metal by removal of oxygen. Much confusion has arisen owing to the fact that electric phenomena are produced by ethereal waves. Indeed, the word "electricity" has a dual signification: firstly, it applies to congeries of negative electrons attached to what is generally termed matter, as one element is united to another—or, to use a more general expression, is attached to another, or to a compound; and secondly, it is made to signify vibrations in the ether, which arise when a current of moving electrons is started or stopped. It is also clear that a magnet is associated with electrons in circular motion, which keep the neighboring ether in a state of strain; if the lines of strain, or "lines of force," be cut by a moving wire, the electrons in that wire are set in motion and a current is produced. It is unnecessary to state that this fact that ethereal vibrations can start or stop electrons has proved of the very greatest service to mankind; to this is due the invention of the dynamo, of the motor, and of wireless telegraphy. But it is evident that such ethereal vibrations, transmitted as waves, are in no sense the material electrons, any more than the force applied by a horse to a rope is the canal-boat which it sets in motion.

As for the mechanism by which ethereal waves effect motion in electrons, that is beyond the scope of these lectures. Indeed, of the rival theories which profess to explain it, not one is satisfactory. All that can definitely be said is that there is an evident gyroscopic action, for motion of

electrons occurs not in the direction of propagation of the ethereal force, but at right angles to it. We therefore deliberately confine our attention to the electron as a form of matter with a known atomic weight, viz., $1/1830$, and capable of forming compounds with what we commonly term matter. And here again we must draw a line. The question has been raised, Does matter consist of congeries of electrons in rotation, or in vibration, or exercising some form of relative motion? Or is there a material nucleus, composed of some entity different from electrons, with which electrons can combine, and from which they can separate? And is there only one such stuff—primordial matter? Or are there as many varieties of stuff as there are elements?

These speculations are of great interest; some of them have exercised men's minds for centuries. But answers to these questions are not yet forthcoming; they are the goals to which investigation is tending. As regards the question of the composition of matter, whether it consists wholly of electrons or not, that must be left open. It can and will be decided by experiments devised to test various theories. All we need say for the present is that most forms of matter, such as we know them, contain electrons as parts of their composition; we need not *yet* concern ourselves with the constitution of the residual matter after the removable electrons have been removed.

As for the unity of matter, I hope to be able to show that progress is being made in the direction of an answer to that question. It may, however, be stated at once that it is as yet absolutely uncertain whether or not matter will ultimately be found to be homogeneous—that is, consisting wholly of one kind, associated with more or with fewer electrons.

Having arrived, then, at the notion that in electrons we must recognize an elementary form of matter, let us next

consider the transference of electrons from one form of combination to another. This can be done most simply by reasoning on any simple electrolysis; and I will choose that of water, assuming, for simplicity's sake, that the change is the theoretical one, $2H_2O = 2H_2 + O_2$. The real change which occurs depends, of course, on the electrolyte which has been added to the water, and on the action of its liberated ions on the water; if it be sulphuric acid, for example, the hydrogen of the acid will be set free, and the sulphation group, SO_4, will liberate oxygen by its action on water. We will neglect these actions, however, and will regard the action as expressed by the simpler equation.

Water, then, consists of molecules of some complexity, probably H_6O_3, or H_8O_4, or mixtures of these with even more complicated molecular groups; and along with them, mingled with the rest, are ions of hydrogen and oxygen. The hydrogen ions are those which lost electrons to the oxygen when the water was produced. It is reasonable to suppose that during the combination of the hydrogen gas with the oxygen gas (granting the water to have been so formed), the hydrogen, which as a gas consists of hydrions in union with electrons, H–H–, has, during its "union" with oxygen, which as a gas may be provisionally taken as O=O, given its electrons to the oxygen; so that on ionization the electrons, having already arranged themselves in the water-molecule in such a manner that they are no longer directly associated with the hydrogen, leave the hydrogen atoms entirely without removable electrons; it is often the custom to call these atoms of hydrogen devoid of electrons, "hydrions." Each electron which has left an atom of hydrogen associates itself with an atom of oxygen plus one of hydrogen, thus:

$$2\mathrm{H}{-}{-}\mathrm{H}{+}\mathrm{O}{=}{=}\mathrm{O} = 2\mathrm{H}{-}\mathrm{O}_{=}{+}\mathrm{H}{+}\mathrm{H}.$$

This equation requires consideration. A molecule of hydrogen is not H–, but $=H_2$. Now it is an open question how the electrons are attached; but it is to be presumed that an electron forms the bond between the two atoms. This may happen in two ways. First, the attachment may be H––; or, second, H–H–. The same reasoning applies to the molecule of oxygen; it may be =O=O or O==O. In the first case one of the atoms is tetrad, according to the usual code of writing; but that need excite no surprise: oxygen is known to possess tetrad valency under suitable conditions. It may be remarked, however, that similar reasoning applied to the hydrogen molecule involves the assumption of dyad hydrogen, and that is an unlikely supposition. It need hardly here be insisted on that the actual practical valency of an element or group is equal to the number of electrons which it carries during electrolysis; that is the corollary of Faraday's law. Now hydrogen is invariably monovalent; hence the formula H––H is preferable to H–H–. On the other hand, it may be objected that two electrons will repel each other, and it might with justice be asserted that for that reason H–H– is preferable to H––H; and similarly that O=O= is preferable to O==O. This statement will be referred to again in the second lecture. Perhaps both formulæ are correct; tautomerism may occur in reference to atoms and electrons as well as between atoms considered independently of electrons; the formula of hydrocyanic acid appears to be both H–C≡N and H–N≡C; and many similar instances will suggest themselves in more definite cases, as, for example, among the enols.

Leaving such questions for the present, let us see the effect of an electric current on hydrions and hydroxylions. They are to be regarded as separate and definite chemical entities intermingled with complex water-molecules—indeed, sur-

rounded by them; for it is in every way probable that the hydrions are attracted by spare electrons of the water-molecules. We have many instances of a similar directive action among compounds; the place of substitution in the benzene ring depends on the position of groups already substituted for nuclear hydrogen. We may therefore believe that the ions both of hydrogen and of hydroxyl are protected by a coating of non-ionized molecules of water. It is, indeed, probable that interchange of electrons takes place between the two, molecules and ions, so that it is not always the same hydroxyl group which retains its electron; the Williamson-Clausius hypothesis of interchange may well be applicable.

Into such a system of molecules and ions two platinum electrodes are plunged. We need not here consider the source of the current; suffice it to say that at the negative electrode the electrons are crowded on the surface, ready to escape on application of sufficient driving force—*i.e.*, of a sufficiently high potential; while from the positive electrode the electrons are subject to strain, for they are being sucked into the connecting wire by a corresponding electromotive force. In fact, we may consider the negative electrode as a region of electric pressure—a kind of electric force-pump; and the positive electrode as a partial electric vacuum—an electric suction-pump.

The hydrions, having no electrons attached to them, are attracted to the negative electrode, where electrons are present under electric pressure; they move thither at a rate depending on the mobility of the ion (and hydrions are the most mobile of all ions) as well as on the viscosity of the liquid, which is itself a function of temperature. Having arrived at the kathode, each ion absorbs an electron, and from a hydrion becomes an atom of hydrogen. Each atom

of hydrogen readjusts its newly found electrons so as to combine with its neighbor atom according to one of the schemes already set forth.

In an exactly similar manner, the kation, the hydroxylion, reaches the anode where electrons are under strain; from each hydroxylion an electron is removed, and the group OH is left without a free valency—*i.e.*, without an attached electron. It may under certain circumstances unite with another hydroxyl group, due possibly to the quadrivalence of the oxygen atoms; they may serve as bonds of attachment of the two groups to each other, thus:

$$\mathrm{O{-}H + O{-}H = H{-}O \equiv\equiv O{-}H};$$

or only one of the three latent electrons may come into play, thus forming

$$\mathrm{H{-}O{-}{-}O{-}H},$$

the others being existent, though not in evidence. Or, as more generally happens, the molecules readjust themselves, forming water and free oxygen according to the scheme

$$\mathrm{O{-}H + O{-}H = H{-}O{-}H + O};$$

and the atom O unites with a neighbor atom of O, forming

$$\mathrm{O{=}{=}O \text{ or } {=}O{=}O},$$

as explained before.

It may be objected that views such as the above are very hypothetical; that they tend to complexity and not to simplicity; and that they are imperfect. To that it may be replied that it is certain that some ions are carriers of electrons, and that others—the positive ions—travel without manifest electrons; that the electron is certainly to be regarded as an element, and that its comings and goings, its entering and escaping from chemical compounds must therefore be chronicled in all complete equations; that the intro-

duction of a new element capable of reacting with other elements necessarily tends toward complexity; and that all first attempts to represent chemical changes are of necessity imperfect, as is witnessed by the enormous progress which has been made in the graphic notation of organic chemistry.

This example will serve to illustrate the electrolysis of any chemical compound; the processes which occur are similar in kind, although they may differ according to the nature of the electrolysis.

Let us next consider what goes on in a simple battery; and we may suppose a plate of platinum and a plate of zinc dipped in a bath of dilute hydrochloric acid and coupled by means of a wire, a galvanometer being inserted to show the direction and electromotive force of the current.

The solution contains chlorions and hydrions, each protected by water-molecules. The more dilute the solution, the more efficient the protection from mutual discharge of the anions and the kations, the greater the ionization of the solution. Concentration of the solution by diminishing the relative number of water-molecules decreases the number of ions of hydrogen and chlorine. These ions are to be supposed, before introduction of the platinum and zinc plates, as evenly distributed throughout the liquid.

The plates are now introduced but not yet joined by a wire. Now, zinc, for some reason which we cannot yet guess at, has a greater tendency to dissolve in water than has platinum. But metallic zinc, which is really a compound of a zincion with two electrons, is insoluble in water; to dissolve, it must lose its electrons. When placed in water which contains some few hydrions, a trace of zinc will doubtless dissolve as ions, while a trace of hydrogen will adhere to the surface of the zinc. But the pressure—the solution-pressure, as it may be termed—will soon cease, and no further action

will occur. On joining the zinc plate to the platinum plate by means of a wire (let us suppose of copper), the zinc begins to dissolve, while for every atom of zinc dissolved a molecule of hydrogen attaches itself to the surface of the platinum, and when the concentration is sufficient it escapes in bubbles.

In order that the zinc shall dissolve it must lose its electrons. These, however, require a channel of escape, which they find in the copper wire. Leaving for a moment the nature of the change which accompanies their transit, let us follow them to the surface of the platinum plate. Here they accumulate, with a pressure (that is, at a potential) equal in absolute measure to the solution-pressure of the zinc plate. The hydrions flock to the platinum plate, for they, lacking electrons, travel to where electrons are plentiful; each hydrion acquires an electron, unites with it, and, as previously explained, joins to a neighboring atom to form a molecule. When these attain a sufficient number to saturate the neighboring water, and the capacity of platinum for holding atomic or molecular hydrogen (probably atomic) is attained, the molecules of hydrogen escape in bubbles.

The chlorions—in the old nomenclature negatively charged, in the new conception containing each an active electron—are attracted to the spot from which electrons are flowing away through the wire. Although they are not otherwise changed, they concentrate in the neighborhood of the anode, from which zincions are being propelled into the solution. The rate of their flow to the anode depends on their specific mobility and on the viscosity of the liquid, a condition of concentration and temperature.

In short, the process taking place in a battery has considerable resemblance to that which causes the flow of a liquid due to osmotic pressure. A concentrated solution, in contact

through a semipermeable diaphragm with a dilute solution, tends to be diluted; the solvent from the dilute solution passes through the semipermeable membrane into the concentrated solution, and lessens its concentration. Now the electrons may be likened to the solvent of the dilute solution; they have alternative courses. The wire is permeable to electrons, but not to ordinary forms of matter; it acts thus as a semipermeable membrane. The pressure may, as in the case of osmosis, be regarded from two points of view: either as that of the solvent entering the concentrated solution through the semipermeable membrane, or as due to the bombardment of the walls of the vessel containing the concentrated solution by the molecules of the contained solute. So the pressure in the battery may be regarded from two points of view: either as the difference between the solution-pressure of the metallic zinc and that of the metallic platinum, or as the difference in the affinity of electrons for zinc and for platinum. It is, however, the property of the electrons to pass along the wire, which differentiates them from what we generally term matter; and, as already remarked, the phenomena in a battery afford a close analogy with those producible by means of osmotic pressure. We have in the battery a stream of electrons passing along the copper wire as long as there is zinc to dissolve in the ionic state, or as long as ions of hydrogen remain in solution to unite with the electrons on the surface of the platinum. This current of electrons may be made use of in several ways; first, it may be employed in electrolyzing an interposed solution—that phenomenon has already been considered. Second, it may serve to heat the wire; the conditions for a great rise of temperature are that the wire shall be thin, and that its conductivity shall not be high. Third, if the wire be coiled, and

if a magnet be suspended within the coil, it will set itself at right angles to the plane of the coil.

Let us first consider the heating of the wire, for that involves the theory of metallic conduction.

All material elements are capable of combination with electrons. Those which are termed bad conductors or insulators, however, do not readily combine; the electrons therefore form a layer on the surface. Such a layer can be produced by friction between two non-conductors—for instance, silk and sulphur. As has been known for a century and a half, "frictional electricity" can be produced by rubbing a silk pad on a cylinder of sulphur. Here the surface of the sulphur is "negatively electrified"—*i.e.,* electrons leave the silk and adhere to the sulphur. If a glass cylinder be substituted for one of sulphur, it is the glass which loses electrons and the silk pad which gains; hence the old names "vitreous" for positive and "resinous" for negative electricity. The rubbing of a metal object also effects the transfer of electrons; but in this case, unless the metal is supported by a non-conductor, the loss or gain of electrons is replaced by conduction from the earth. The electrons spread themselves all over the surface of the metal, instead of adhering in patches, as they do if non-conductors be rubbed.

When a salt is dissolved in water it is the metallic portion which loses its electron or electrons, and the non-metallic portion which gains them. We may therefore conclude that metals have less tendency to combine with electrons than non-metals, and that the more "metallic" an element, the less its tendency to hold electrons. It is therefore to be expected that in a metal wire, if electrons are introduced at one end, they will displace those in combination with the metal at the hither end of the wire, and that this process will go on con-

tinuously, so that if it is possible for electrons to escape at the further end, they will pass from one end of the wire to the other. This will also happen with rods or wires of poor conductors, but not with actual non-conductors. Transparent fused salts, or oxides, such as rock-salt, glass, or silica, are practical non-conductors. Their only method of conduction is an electrolytic one, and the mobility of their molecules and ions is so small that they cannot serve to convey electrons. But in a copper wire the transfer of electrons is easily effected.

The result of the passage of a current through a poor conductor of small section is to heat it. This heat corresponds quantitatively with the resistance which it offers to the passage of the current. It may be conceived that the electrons form relatively stable compounds with the atoms of the element of which the resisting wire is composed, and that in order to facilitate their passage the atoms are obliged to readjust their position relatively to each other; hence friction and heat. It would follow that the electrons do not flow as a stream through the interstices between the atoms, but that they form temporary and unstable compounds with the metal as they flow. It must, however, be acknowledged that this explanation lacks completeness, which further experiment will doubtless assure.

It is somewhat beyond the scope of these lectures to consider the action of a stream of electrons on the position of a magnet. The flow of electrons, it may however be remarked, produces a strain in the ether which interferes with the rotation of the electrons round the atoms of a magnetized bar. These set themselves at right angles to the plane of the wire carrying the current. Conversely, a forcible displacement of the magnet will cause a shift of electrons in the wire. But, as before remarked, owing to lack of definite-

ness in our ideas of the natüre of the ether, no perfect picture has yet been made of the mechanism of its action.

We are more and more impressed with the necessity of a mechanical conception of things around us; all recent discovery shows that things much too minute for us to see are constituted in a manner not unlike the objects apparent to our senses. Hence we must regard the atoms of electricity —the electrons—as capable of taking up position in a chemical compound, just as we have imagined the atoms to do. It is true that we cannot maintain that the atoms are without motion. Far from it. But we can with fair probability determine the position of their centers of oscillation or rotation. The structure of compounds, viewed from the electronic point of view, will form the subject of the next lecture.

LECTURE II

COMPOUNDS OF ELECTRONS

WE have already considered one compound—namely, water—from the point of view of the shift of electrons during the reaction of gaseous hydrogen and oxygen. It may conduce to clearness, however, if similar considerations are applied to the case of sodium chloride, one method of preparing which, though far from a commercial one, is the "direct union" of sodium with chlorine. It may be remarked, however, that union does not take place between perfectly dry chlorine and clean sodium; it appears to be necessary that a trace of water-vapor be present. The rôle played by the water will be considered later.

On the electronic hypothesis, sodium, the metal as we know it, is a compound of an atom of sodium with an electron. Chlorine, too, is a compound of an atom of chlorion with electrons; and inasmuch as in the perchlorates chlorine functions as a heptad, it would perhaps be proper to indicate that fact whenever the chlorine symbol is written. A convenient method is to affix to the symbol of the element the Roman numeral VII; thus, Cl^{VII}. These electrons, however, so far as we know, play no part in the union of sodium with chlorine; hence it is permissible to omit them for the present. It is, however, to be noted that the addition of one more electron to chlorine raises the total number of attached electrons to eight; and this appears to be the highest number of electrons with which an element can be associated.

The equation $Na{-}+Cl=Na{-}Cl$ does not accurately express the whole change, for that is undoubtedly preceded

by the change $Cl--Cl = Cl- + Cl-$, and the simple atoms of chlorine are available for combination. It is, of course, possible that the chlorine molecule persists by reason of the interaction of several electrons; then Cl^{VII} may be attached to its neighbor Cl^{VII} by many "bonds"; $Cl^{VI}--Cl^{VI}$ would express the case already mentioned; but $Cl^{V}==Cl^{V}$ or $Cl^{IV}\equiv\equiv Cl^{IV}$, etc., would equally well represent combinations of the sort. In the absence of any positive evidence, the simplest hypothesis may be adopted, and the abbreviated form $Cl--Cl$ chosen.

Union between an atom of sodium and one of chlorine consists, in all probability, in the use of the electron of the sodium. The formula $Na-Cl^{VII}$ would appear to represent the compound, because as soon as that salt is dissolved in water the electron is undoubtedly associated with the chlorine atom; we have Na, surrounded by water-molecules on the one hand, and on the other, $-Cl^{VII}.Aq$. Now sodium chloride does not differ in properties from its solution, except in so far as the ions are free to migrate after, but not before, it is dissolved. The salt has a specific refractivity; its solution possesses a refractivity practically the mean of that of the salt and the water, taken in the proportions in which they are present in solution. It has also a mean specific heat, and, in short, many other physical properties of the same order. It is therefore more than probable, if the existence of electrons be granted at all, that the change in position of the electron originally attached to the atom of metallic sodium has taken place during the formation of the sodium chloride. And on solution in water, the new system divides: the sodium ion, surrounded by attracted water-molecules, constitutes one practically independent unit, Na.Aq; while the chlorine ion, $-Cl^{VII}Aq$, has also reached independent existence. This is proved by the fact that these entities

exert each its own calculated osmotic pressure; and furthermore, that the chlorion can be attracted to a metallic anode, and the sodion to a metallic kathode, placed in the solution. Similar reasoning may be applied to the ordinary hydroxides of the metals, even to those which are ordinarily regarded as insoluble; for insolubility is only a relative term, and reactions between hydroxides and acids are no doubt only effective as regards that portion of the hydroxide in solution; because, when withdrawn, and after reaction with the acid to form a salt and water, it is at once and continuously replaced, according to well known laws, by a further portion which goes into solution as ions of metal and acid-radical. It may be imagined that the attack of a metal like sodium by chlorine, which depends on the presence of a trace of moisture, has also to do with the action of the metal on the water. It is, however, not so easy to give a reason. For the loss of energy due to direct formation of salt from sodium and chlorine is obviously, according to Hess's law, the same as that which ensues when salt is formed indirectly, according to the usual scheme $2Na + 2HOH = 2NaOH + H_2$, $H_2 + Cl_2 = 2HCl$, and $2NaOH + 2HCl = 2NaCl + 2HOH$; the molecule of water being regenerated. It may be that such a system permits of the easier transfer of the electrons; this answer, however, begs the question; or it may be that either the chlorine or the sodium, or both, enter into combination with the water-molecules, making use of the latent electrons of the oxygen, thus: $H_2{=}O{=}Cl_2^{VII}$ and $H_2{=}O{=}Na_2$, and that these subsequently interact with one another. This, however, opens a question, afterward to be considered, relating to the source of the electrons, which are depicted as bonds between the oxygen and the chlorine on the one hand, and the oxygen and the sodium on the other.

The case of salts in general is analogous to that of the

chlorides and hydroxides. The "acid radical" is in itself an ion, carrying with it, according to its basicity, mono-, di-, tri-, etc., one, two or three electrons. Thus the group $=SO_4$ has doubtless two available electrons; $\equiv PO_4$, three, and so on. The portion of those salts, generally regarded as insoluble, which is in a state of solution contains such ions; and, indeed, a determination of the conductivity of the very sparingly soluble salts affords an elegant plan of determining their solubility.

In certain cases ionization does not occur so simply as to be represented by a metallic anion and a non-metallic kation. Compounds such, for example, as cupric chloride ionize, at least partially, into Cu.Aq and $=CuCl_4$.Aq. Indeed, it may be stated that this behavior is the rule, and simple ionization the exception. The fluorides and the cyanides are particularly prone to undergo such ionization when dissolved. On the other hand, salts like the alums and the double sulphates, when treated with water, give solutions in which the simpler ions form the major part of the ions present, although no doubt accompanied by a certain percentage of more complex ions, according to the nature of the salt, the degree of dilution, and the temperature. There can be little doubt, however, that in the solid state, or in the crystalline form, with water of crystallization, it is the complex ions which are present. For instance, a partial formula for potash alum in the crystalline state would be $K-\{Al(SO_4)_2\}.12H_2O$; although in solution the majority of the ions are K.Aq, Al.Aq, –OH.Aq, and $=SO_4$.Aq.

It is customary to call salts which possess mainly the latter character "double salts," and those which, like $K_4Fe(CN)_6$, $KAg(CN)_2$, Na_2SiF_6, etc., ionize according to the more complex scheme, "complex salts." But this classification, although convenient, is not exclusive. It is probable—nay,

certain—that Ag ions are present in a solution of potassium argentocyanide because silver can be electrodeposited from its solution. And although it would be impossible to prove that a measurable amount of the silicon ion is present in a solution of sodium silicifluoride, it must be regarded as an extreme case.

Change of valency permits of easy representation on the electronic hypothesis. As an illustration the ferrous and ferric salts may be cited. Supposing the ionization of the chlorides to occur according to the simple scheme, then ferric chloride is $Fe{\equiv}Cl_3^{VII}$, and ferrous chloride, $-Fe{=}Cl_2^{VII}$. The third electron, present in combination with the ferrion in metallic iron, plays no part in the structure of ferrous chloride, but remains latent. It can be brought into action by chlorination, or by oxidation, when the iron "changes its valency." Perhaps the speculation may be here allowed that iron, associated with three electrons, is a less easily attackable body than when one electron is latent. What "latent" in this connection signifies is merely that the latent electron is not so easily transferred as the others. In iron, for example, as in all other elements, the maximum number of electrons associated with an atom appears to be eight. Even when the iron "acts as a triad" there must still be five latent electrons attached to the iron atom—electrons, that is, which play no part in ferric compounds. Some of them, however, are essential when the metal acts as a ferrate, of which more hereafter.

So far, the symbol – (the usual one for a valency or bond) has been employed to denote an electron. This has the convenience of long-established custom; and it also fits in with the resemblance of the dash to the negative sign, and may be

taken also to imply a unit charge of negative electricity associated with the compound or atom. But that sign does not show what direction the electron has taken during the formation of a compound. The idea of direction is easily introduced by the conventional barb of an arrowhead; and Na→Cl may signify that during the formation of salt the electron which couples the two atoms was the one which was originally attached to the sodium when it was in the metallic state; and also that on solution in water it will form part of the chlorion.

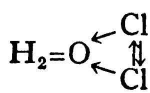
We have now to consider the electronic formulæ of certain more complex compounds; and as examples two shall be chosen, viz., hydrogen fluoride and ammonium chloride.

In the gaseous state the formula of hydrogen fluoride is H_2F_2; and in solution, $H_2F_2.Aq$. How are the electrons distributed? It is known that hydrofluoric acid may ionize in two fashions: $H.Aq + -HF_2.Aq$ and $2H.Aq + =F_2.Aq$. In the first case the second hydrogen atom does not enter the solution in the ionic state. How is it attached? And how are the two atoms of fluorine combined together? Answers to these questions must necessarily be of a speculative nature; but it appears best to set up a provisional theory which must stand the test of experience and prove compatible with the constitutions assigned to other compounds.

It appears to me that it must be concluded that an atom may have the power both of giving and taking an electron. If a hydrogen atom parts with an electron to a chlorine atom, so that the electron is more closely associated with the chlorine than with the hydrogen atom, then, on solution in water, the hydrion will separate as an entity. If, however, the hydrogen atom H– not merely parts with an electron to an

atom of fluorine, but receives one in return, then: $H \rightleftarrows F$; the hydrogen ion does not separate on addition of water. But by this process the fluorine atom has acquired the property of disposing of an electron which would otherwise remain latent. This serves as the bond of connection between the two fluorine atoms. It may be expressed thus: $H \rightleftarrows F \leftarrow F \leftarrow H$; the kation will then be $H \rightleftarrows F \leftarrow F \leftarrow$, and the anion H.

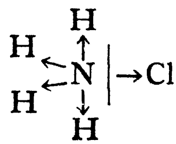
In this manner it may be conceived that a molecule of chlorine may be constituted: $Cl \rightleftarrows Cl$; and its combination with water, preliminary to the attack of sodium, would be thus represented:



Let us next consider the case of ammonium chloride. Here we have the group NH_4Cl, which on solution yields the ions (NH_4).Aq and $-$Cl.Aq, similar to common salt. So far the case is clear. How is the group NH_4 to be represented?

The hydrogen of the hydrogen chloride has already given its electron to the chlorine; it has, by hypothesis, no electron to bind it to the nitrogen atom. The effective electron must therefore come from the nitrogen. But there is no known difference between the four hydrogen atoms of ammonium chloride. Of course it is true that when heated one hydrogen atom associates itself with the chlorine (when the vapor is damp); but, so far as is known, any one of the four hydrogen atoms may do so. It may be remarked, in passing, that the fact that two varieties of tetra-substituted ammonium chloride exist has no bearing on the question before us. That has purely stereo-chemical reasons. I suggest as one

solution of the problem that the nitrogen atom parts with its electrons to all four hydrogen atoms, thus:



the fifth having become the bond to the chlorine atom. In solution, the group NH_4 is left. The vertical line shows how ionization occurs on solution in water.

This opens the general question, How are the electrons attached in the case of non-ionizable substances, such as PCl_3 or CH_4, to choose only two among almost innumerable instances?

It may be taken as certain that the acidity of an acid is due to the hydrion, H, which accompanies its solution in water; and the residual group may be depicted as $A\leftarrow$. From this it may be argued that, as a rule, where the compound is non-ionizable, not only is the hydrion absent, but the disposition of the electron is such that ionization cannot occur; the hydrogen does not part with its electron to the other element or group. But if the hydrogen were to retain its electron and suffer no further change, it is to be presumed that it would still retain the properties of the element; hence some change must have occurred. Indeed, there are only three possibilities: (1) that the hydrogen parts with an electron, and that has been shown to be practically impossible; (2) that it receives one; and (3) that both its own electron and the one which it receives are the cause of its staying in combination. The first case may be represented, as before, by $A\leftarrow H$; the second, by $X\rightarrow H\rightarrow$; and the third, by $X\rightleftarrows H$.

We know only that methyl iodide, CH_3I, is not generally

regarded as an ionized compound, and yet, on long shaking with a solution of silver nitrate, silver iodide is formed even in aqueous solution. This precipitation takes place more rapidly in alcoholic solution, probably because of the more intimate contact between the reacting bodies. Now the usual representation of such a fact would be $(CH_3)|\rightarrow I$. The group CH_3 has a positive charge; it has lost an electron to the iodine, which has become iodion, $\rightarrow I$. The explanation has already been given in the case of ammonia; it may be symbolized thus:

$$\begin{array}{ccc} & H & \\ & \uparrow & \\ H\leftarrow & C & \Big|\rightarrow I \\ & \downarrow & \\ & H & \end{array}$$

This leads us to consider the hydrocarbon CH_4; and it may evidently be represented on the same scheme, viz.:

$$\begin{array}{ccc} & H & \\ & \uparrow & \\ H\leftarrow & C & \rightarrow H \\ & \downarrow & \\ & H & \end{array}$$

No one of the hydrogen atoms is replaceable; they are all negatively electrified—*i.e.*, to use an exaggeration which will be understood, they are more negatively charged than gaseous hydrogen itself, each atom having received an extra electron. Just as metallic zinc can be preserved from attack by imparting to it a powerful negative charge, so these atoms of hydrogen are rendered inactive by virtue of the protective electrons which they receive from the carbon atom.

Analogous reasoning will prove applicable to compounds like phosphorus chloride; here the electrons possibly come

from the phosphorus atom and from the junctions with the phosphorus atom, thus:

$$Cl \leftarrow P \begin{matrix} \nearrow Cl \\ \searrow Cl \end{matrix}$$

The addition of two atoms of chlorine to form phosphoric chloride would be too speculative to interpret; and it may be remarked that the electrons are probably also derived from the phosphorus.

Let us now return to the halogens, and examine their valency in the light of the electron theory. According to the ordinary view, the acids are, as a rule, dehydrated hydroxides; the elements with high valency do not form normal hydroxides; the known compounds are derived from these hypothetical compounds through loss of water. A single example will render this clear, and the case of chlorine is instructive. The oxy-acids of chlorine are: HClO, hypochlorous acid; $HClO_2$, chlorous acid; $HClO_3$, chloric acid; and $HClO_4$, perchloric acid. In the first of these chlorine functions as a monad; in the second, as a triad; in the third, as a pentad; and in the fourth, as a heptad. The normal hydroxides would be: (1) ClOH; (2) $Cl(OH)_3$; (3) $Cl(OH)_5$; and (4) $Cl(OH)_7$. The first is known as such; the ordinary formula of chlorous acid, as revealed by its salts, is O=Cl–OH; that of chloric acid, $(O_2)^{IV}Cl–OH$; and of perchloric acid, $(O_3)^{VI}Cl–OH$. Now while caustic soda ionizes into hydroxyl and sodium, –OH and Na, hypochlorous acid, which displays some small extent of ionization, in solution gives (ClO)– and H as its ions. And since it is clear in the first case that the atom of sodium metal, in becoming hydroxide, has given an electron to the oxygen, while hydrogen is still retained by the oxygen, the direction of electrons must be $\rightarrow O \leftarrow H$, or possibly $\rightarrow O \rightarrow H–$, or pos-

sibly $\rightarrow O \rightleftarrows H$; in the last case the hydrogen electron as well as that pertaining to the oxygen taking part in the union. Similarly, when hypochlorous acid ionizes, the ions are $(ClO)-$ and H; it is clear that the hydrogen atom has parted with its electron to the group (ClO), and probably to the oxygen atom; we may therefore write its formula $ClO \leftarrow H$. How are the chlorine and oxygen atoms connected?

The highest valency of any element appears to be eight; and in perchlorates that of chlorine is seven. It would be possible for the heptavalent chlorine—*i.e.,* the atom of chlorine stuff combined with seven electrons—to absorb an eighth. That must be supposed to occur in hydrogen chloride; hence we may write its formula $Cl^{VII} \leftarrow H$, the Roman numeral VII expressing the electrons already attached. The formula $Cl^{VII} \leftarrow O \leftarrow H$ would thus portray the condition of the electrons. This, however, gives no clue as to the splitting off of an electronless hydrion in preference to the hydroxyl group $\leftarrow O \leftarrow H$. It may therefore be imagined that one or more of the seven electrons of the chlorine atom take part in retaining the oxygen atom. And this becomes a necessity when we consider one of the higher acids. Were each oxygen atom of perchloric acid to transfer one or two electrons to the chlorine, the latter would be overladen. Hence electrons must be derived from the chlorine; and if each atom of oxygen requires two electrons to bind it (except the hydroxyl oxygen, which, having received one already from the hydrion, will be content with one more), then the formula of perchloric acid may be written:

$$\begin{array}{ccccccc} & O & & O & & & \\ & & \Nwarrow & \Nearrow & & & \\ O & \Leftarrow & Cl & \rightarrow & O & \leftarrow & H \\ & & \Downarrow & & & & \\ & & O & & & & \end{array}$$

Chloric acid may be similarly represented; but the chlorine

symbol should be written Cl^{II}, to signify that it still retains two electrons; and the chlorine in chlorous acid retains four out of the seven. These electrons correspond to what have sometimes been called "contra-valencies" (see Abegg's publications).

It is not necessary to multiply instances; the electronic constitution of all the oxy-acids can be thus represented.

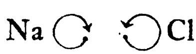
We have now a clue to the constitution of the oxides and anhydrides. Orthocarbonic acid, as represented by its esters, will have the formula $C(\rightarrow O \leftarrow H)_4$; carbonic acid, $O \Leftarrow C(\rightarrow O \leftarrow H)_2$; and it follows that CO_2 must be $C(\Rightarrow O)_2$. By analogous formulæ we can represent all the oxides and sulphides of the metals.

The unsaturated oxides call for a short comment. We have CO, also ClO_2, NO and NO_2, as somewhat outstanding compounds. As for CO, it may be treated like the other oxides; or again, it may be that the electrons concerned come from the oxygen, thus: $C^{IV} \Leftarrow O$. The hypothesis, as formerly suggested, that one electron has been derived from the oxygen, the other from the carbon atom, thus: $C^{IV} \rightleftharpoons O$, is not excluded. This would appear, on the whole, the most probable assumption, for in that case the valency of the carbon is not disturbed. On this hypothesis, the formulæ of chlorine peroxide, of nitric oxide, and of nitric peroxide would be $Cl^{VII}{\begin{smallmatrix}\leftrightarrows O\\ \leftrightarrows O\end{smallmatrix}}$, $N^{V} \rightleftharpoons O$, and $N^{V}{\begin{smallmatrix}\leftrightarrows O\\ \leftrightarrows O\end{smallmatrix}}$, respectively.

We now see that the maximum number of electrons with which an element can be associated is eight. When some of these are employed in holding together the constituent atoms of compounds, the remainder are "latent"; they may under certain circumstances come into action, and in some instances the acting electrons are derived from both constituents of a binary compound. Here we have, perhaps, an explanation of amphoteric bodies—bodies like zinc hydroxide, which can

function either as a base or as an acid. In the former case the electrons would appear to be arranged thus: $Zn(\rightarrow O \rightarrow H)_2$; in the latter, thus: $Zn(\rightarrow O \leftarrow H)_2$. In all probability the oxide is a zincate of zinc, for which an appropriate electronic formula can easily be worked out.

We come next to the consideration of how the electrons form ties between the atoms of compounds; and this must necessarily be of a speculative character. But we have one *point de départ.* We know that a stream of electrons repels a similar stream of electrons passing in the same direction, and attracts a stream of electrons passing in the opposite direction. Reasoning which applies to a number of electrons in all probability applies to single electrons, and it is known to be equally applicable to curvilinear as to straight-line motion. Assuming that the electron connected with an atom of metallic sodium is rotating in a clockwise direction, viewed from the center of the atom, and one of the seven normally attached to an atom of chlorine is rotating in an anti-clockwise direction, combination may be supposed to take place when their planes of rotation become parallel, thus:



Solution in water leaves the sodium atom minus its electron, which remains attached to the chlorine atom.

The applicability of this conception to the position which substituents take up in carbon compounds, and to the influence of groups already present on such position, is easily seen and need not be enlarged on, but they form a not unimportant part of chemistry. The influence exerted on atoms by neighboring atoms and groups also finds ready explanation, and many instances will at once suggest themselves.

Certain compounds show absorption spectra; others do

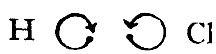
not, so far as is known, absorb light either in the visible or invisible spectrum. From Zeeman's experiments and Lorentz's theory it is clear that the circular paths usually followed by electrons can be changed to elliptic ones; here we have to some extent a proof that the permanent circular motion of electrons in compounds is not imaginary. Under the influence of a magnetic field, all compounds which transmit polarized light rotate the plane of polarization; here we have the magnet arranging the planes of rotation of the already rotating electrons, so that they affect ethereal waves passing in their neighborhood.

These rotating electrons represent the "tubes of force" which have sometimes been imagined as the mechanism of chemical attraction. As yet we cannot account for the fact that two electrons, moving in opposed parallel paths, attract each other; it is merely another instance of the inexplicable problem of "action at a distance," which has puzzled all philosophers since the time of Newton and earlier, and even now we are no nearer an explanation. What can be done, however, is to trace the connection between the now known fact that chemical elements and compounds invariably, so far as we know, contain electrons among their constituents, and the mechanism of a compound containing electrons in motion.

In this lecture many of the conceptions are similar to those put forward in the author's presidential address to the Chemical Society of London in March, 1908; hence no allusion has been made here to the possible explanation of the constitution of some complex compounds by the electronic hypothesis; nor has the theory of isorrhopæsis, developed by Baly and his school, been touched on. Reference to the published papers will show how easily their conceptions fit the theory of electrons. It must be distinctly noted that much

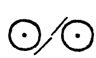
of what has preceded is now no longer hypothetical, but actual statement of fact. The electron is no mythical conception, and that it enters into the constitution of matter is as certain as that matter exists.

The combination of one hydrogen atom with another to form a molecule may finally be again considered. Suppose that the constitution of the atom is such that the electron is not free to shift its position on the surface of the molecule, which may be taken as a sphere. If two such atoms have electrons rotating in circular paths on their surfaces in a clockwise direction, then, when the sides of the atoms furnished with electrons are opposite, the electron on one atom will be rotating clockwise, while that on the other will be anti-clockwise, when viewed from the same point. Their orbits being in opposite phase, they will repel. If, however, one is rotating in clockwise and the other in anti-clockwise fashion, as is probably the case with H and Cl, they will attract. This may be depicted thus:



or in abbreviated form, H--Cl.[1]

[1] Note added May 23, 1915: Experiments with models have shown that when two spheres, representing two atoms of hydrogen, each provided with a coil of wire, through which an electric current is passing (so as to imitate the path of an electron), are placed near each other they set themselves (seen from above) in such a position that the two coils of wire lie in the same plane, thus:—



Lecture III

THE DISRUPTION OF THE SO-CALLED ELEMENTS

THE mechanism by which one element is retained in combination with another has been a matter of frequent speculation. That the properties of atoms depend on their shape was an idea held by the ancients; pointed atoms giving an acid or "sharp" taste to solutions containing them, while the impression of sweetness was imagined to be due to the spherical and smooth nature of the atoms of sugary bodies, and their soothing action on the organs of taste.

After tables of affinity, showing the order of preferential combination of elements with each other, had been drawn up by Bergman of Sweden in the early half of the eighteenth century, the hypothesis was revived that one element is attached to another by means of hooks capable of interlacing. The mechanical nature of this suggestion was at that time hardly a recommendation; and in determining the proportions in which atoms combine, the mechanism of their combination was tacitly ignored.

The prominence given by Frankland and his school to the doctrine of valency, and the important advances in the theory of organic chemistry made by Kekule in the sixties of the nineteenth century, again directed attention to the subject. Although no clear conceptions were formulated, combination was represented by dashes, to which the name of "bonds" or "affinities" was ascribed. Each element capable of combining with or of replacing one atom of hydrogen had attached to its symbol one "bond" or dash, and was termed "monovalent," or a monad; one with the power of retaining

or of replacing two atoms of hydrogen had two "bonds," and was termed a dyad, or divalent; and so with the rest. But no mechanical idea of the nature of these bonds secured acceptance; they were regarded as arbitrary symbols with the signification ascribed to them above.

The fact that less heat is evolved on making attachment of one carbon atom to another by a "double" than by a "single" bond made it improbable that such bonds were of the nature of links or hooks; and the almost thermal neutrality of the "triple" bond strengthened this impression.

Such views, indefinite as they were, tacitly assumed that two atoms when they combine do not interpenetrate; indeed, the notion of an atom as an indivisible entity precluded the conception of interpenetration. But the advance of knowledge, which has rendered it conceivable that atoms may consist of congeries of electrons, now makes it not impossible that the combination of one atom with another may be attended with interpenetration, the one system of electrons entering the other and establishing a more complicated system. Sir J. J. Thomson, some years ago, threw out the ingenious hypothesis that the combination of atoms may be due to the annular rotation of one vortex-ring round another; and he adduced interesting speculations on the number of rings capable of taking part in such annular rotation, and the stability of the resulting system.

But these speculations were anterior to the discovery of the electron as a chemical element; and though by no means to be lost sight of, they may be allowed to stay in the background for the present.

In this lecture I shall attempt to put together evidence which, I hope, will eventually accumulate so as to throw light on the whole question. It will be remembered that in the second lecture the speculation was made that the staying in

combination of two atoms was possibly due to the attraction exercised by their "valency" electrons rotating in similar directions. We have now to consider whether any means can be discovered which will disturb such a system, and by setting free ions in such a condition that they can be examined, light may be thrown on the mechanism of combination; furthermore, whether means are at our disposal of still more fundamentally altering the motion and distribution of the atoms of the "elements," so that a change of the nature of transmutation of one element into another can be effected.

For this end three lines of argument may be adduced. These are:

1. The evidence of the spontaneous disintegration of the radioactive "elements."

2. The evidence that disintegration of a somewhat similar nature occurs in the stars.

3. The evidence that by applying concentrated forms of energy to the common elements, these can be made either to undergo reversible changes, consisting in the loss or gain of one or more "valency" electrons, or to lose more fundamental electrons, and so to undergo "elemental change," or transmutation.

1. The first line of evidence is now so well known that it may be treated in a cursory manner. The discovery by Henri Becquerel that an electroscope is rapidly discharged when in actual communication, by means of a tube, with a vessel in which a salt of radium was contained, was followed by the discovery, by Schmidt, of the transmissibility of a gaseous educt of thorium through a tube. The determination of the nature of this substance by Rutherford and Soddy; the

establishment of the similar nature of the body emitted from salts of radium now known as niton; the proof of its gradual "decay" and reproduction from its parent substance at such rate as to keep the total amount present in contact with the parent body in a state of equilibrium; the naming of these bodies "emanations"; their condensation by liquid air; and lastly, the theory of disintegration applied to such bodies,—all these constitute one of the most brilliant chapters in the history of chemistry.

The subsequent discovery by Ramsay and Soddy, in 1903, of the fact that one of the products emitted during the disintegration of radium and of its emanation was the now well known element helium, and the determination of the gaseous nature of radium emanation by the same investigators; the mapping of its spectrum by Ramsay and Collie, by Cameron, and more accurately by Royds and by Watson; its liquefaction, the measurement of its vapor-pressures, its boiling-point, its critical point, and lastly of its density by Ramsay and Whytlaw-Gray, established the claim of radium emanation to be ranked among the "elements," and to have ascribed to it the systematic name "niton" and the symbol Nt; for its inactivity proves it to belong to the series of inert gases, of which argon is the best known.

It has also been shown by many investigators that from thorium and its educts helium is evolved during their disintegration; and by Debierne, the discoverer of actinium, that it, too, yields helium during its radioactive changes.

Not merely this: the number of atoms of helium evolved during the various changes has been ascertained. The emission of a helium atom takes place with an atomic explosion; the atom evolved has a high velocity—so high that it ionizes any gas through which it passes, and renders the ionized gas capable of discharging an electroscope. It was Becquerel

who first recognized this fact, and who characterized such moving atoms of helium (their nature, however, being at that time unknown) as α-rays, to distinguish them from the even more rapidly moving β-rays, now known to be electrons in motion. Confining our attention for the present to the α-rays, they are known to be evolved when radium disintegrates into niton and helium; for each atom of radium, one α-particle, or helium atom, is evolved. Next, when niton disintegrates, forming radium A, α-particle is again expelled; the spontaneous change of radium A into radium B, however, is accompanied only by the emission of electrons in motion, or β-rays; but the changes of radium B into radium C, and of radium C into radium D, are each accompanied by the emission of an atom of helium. There are in all four atoms of helium expelled between radium itself, the great-great-grandfather, and radium D, the great-great-grandson, and three between niton and radium D. It is not necessary to pass further down the scale, for the life of radium D is a comparatively long one. But three atoms of helium are expelled during the change of niton into radium D, and this fact has been verified by Ramsay and Whytlaw-Gray by aid of the microbalance.

It may be taken as certain, therefore, that radium, as well as thorium and actinium, which undergo analogous changes, is the ancestor of numerous elements. Of the elementary nature of radium and of niton, according to the usual interpretation of the word "element," there can be no doubt whatever; for the former has been isolated in a metallic state by its discoverer, Mme. Curie, and is said closely to resemble barium, an element to which its salts bear a close resemblance; while niton, as previously remarked, bears a close resemblance to the inactive elements of the helium and

argon series, and is a congener of neon, krypton, and xenon, *as shown by its physical properties and by its spectrum.*

Here, then, we have spontaneous transformation of one *elementary form of matter into others. The "elements" are not elementary, but some of them at least are only compounds* of exceptional nature, spontaneously capable of decomposition. It remains for us now to determine whether "elements" other than "radioactive elements" are capable of change; and inasmuch as the time required for changes of the kind varies enormously, from millions of years for the change of uranium into radium, of which it appears to be the grandparent, to a few seconds, the half life-period of actinium emanation, it is reasonable to suppose that the periods of change of the older and commoner elements may be enormously long—so long, indeed, as to elude human observation.

But another phenomenon attending the spontaneous change of the radioactive elements must not be left out of sight: the changes alluded to are all accompanied by enormous evolution of heat; they are in the highest degree exothermic; and conversely, if it were possible to produce such radioactive elements by inducing their products of disintegration to combine, an enormous absorption of energy would be essential. Bodies formed by absorption of energy are termed "endothermic"; they are not infrequent among compounds, and they are among the least stable. It is, however, by no means certain that the ordinary elements, which we generally reckon as stable, are endothermic; they may be exothermic, in which case we should expect them to exist indefinitely without change, provided they are not made to receive energy. An analogous case, familiar among compounds, is ammonium chloride. Left to itself, it may be kept for an indefinite time; but when heated to 360° C. it dis-

sociates into ammonia and hydrogen chloride. May it not be the case that the ordinar "stable elements" are in this sense similar to ammonium chloride; that as long as they are not made the recipients of large quantities of energy they remain as they are; but if subjected to an accession of energy, either in the form of heat or of kinetic energy, they may fall apart into simpler forms of matter?

This leads us to the second line of evidence; but before considering it, it may be reiterated that the behavior of the radioactive forms of matter conclusively shows that bodies which have until recently been classed as elementary are in continual process of "disintegration," or, if they be regarded as compounds, of "decomposition."

2. The second line of evidence is dependent on an examination and classification of the spectra of the fixed stars. This work has been accomplished by Sir Norman Lockyer during the past half-century. The arguments for the view that the high temperature of some stars is producing the disintegration of the common elements has been developed by Lockyer in his work entitled "Inorganic Evolution."

In 1864 Mitscherlich showed that certain compounds when heated gave spectra peculiar to themselves and revealing no trace of the elements which they contain. These spectra of compounds present a fluted appearance, the fluting consisting of numerous lines arranged in regular order, and of different intensities. Lockyer showed that at higher temperatures such compounds can be made to exhibit the spectra of the elements which they contain, and the spectra of the elements are characterized by fine lines; the flutings disappear with rise of temperature, to be replaced by the elementary line-spectra.

The effect of rise of temperature on a solid body, such as platinum, is, first, to produce a grayish-white light; this is

succeeded by a dull red, and we say that the solid is "red-hot." A higher temperature increases the amplitude of vibrations, so that the substance emits more light but it diminishes the wave-length, so that the light emitted grows yellower; we may term it "yellow-hot." The next stage is the advent of still shorter vibrations in the green, and when some blue is added the solid is "white-hot," for the combination of these colors produces on our eyes the effect of white light. At a still higher temperature violet light is emitted in quantity, and we might characterize the color seen as "blue-" or "violet-hot."

Taking these colors as a test of the temperature of the stars, Lockyer points out that it is reasonable to group the stars accordingly; and the line spectra of the gases in the stars can then be allocated to a qualitative scale of temperature.

It is possible to imitate similar conditions, although imperfectly, with terrestrial means. The flame is less hot than the arc; the arc gives a lower temperature than the electric spark; and it is possible, by means of powerful discharges, to increase considerably the temperature of the spark. On submitting various ordinary elements to such an ascending scale of temperature, Lockyer noticed that certain spectrum lines became "enhanced,"—*i.e.*, appeared stronger and brighter,—while others diminished in intensity.

On examining the spectra of the stars, it was found that the "enhanced" lines of certain elements were much more prominent in certain stars, and indeed were uncontaminated with the ordinary lines of the elements; these had vanished. Indeed, all stages of change can be followed in the stars; and it is to be noted that as the temperature of the star is higher, the spectra of hydrogen and helium appear, along with spectral lines at present not identified with those of any

terrestrial element. The appearance of these unknown lines is accompanied with the disappearance of the spectrum of the "common" elements, calcium, iron, etc. To the new spectra Lockyer ascribes the coming into existence of new elements, to which he gives the name "proto-elements," regarding them as formed by the disintegration of those known on earth; for instance, he has evidence for the existence of "proto-calcium," "proto-manganese," etc. These "proto-elemental" spectra in still hotter stars are absent, and are replaced by the spectra of helium, oxygen, nitrogen and carbon, along with some unidentified lines; and in still hotter regions, when the spectrum of helium has disappeared, there remains a spectrum whose wave-lengths are related numerically to those of hydrogen, and to this Lockyer has given the name "proto-hydrogen."

If Lockyer's observations and explanations are correct, it would follow that with increase of temperature, matter as we know it undergoes continuous simplification; being finally reduced to one kind, "proto-hydrogen." Whether this final conclusion can be accepted may be left for the present; but as regards his main contention there appears to me to be no manner of doubt.

3. We now pass to the third line of evidence. Let us consider how energy may be applied to "elemental" matter so as to produce disintegration.

First, as regards the nature and amount of energy available two sources present themselves. It is known that both the α-particles—*i.e.*, atoms of helium—and β-particles, or corpuscles—*i.e.*, atoms of electricity or electrons—are emitted from radium and its disintegration-products with enormous velocity. The usual expression for the kinetic energy of a moving body is $\frac{1}{2}mv^2$, where m stands for mass and v for velocity. It was shown by Clerk-Maxwell, many years ago,

that the kinetic energy of gaseous molecules could be thus calculated in agreement with experimental results connected with their pressure and temperature. As shown by Joule, kinetic energy can be numerically expressed in heat-units; and the velocity factor of kinetic energy, v^2, corresponds to temperature. This method of presentation has been chosen here because the dissociation of exothermic compound bodies is always a function of temperature; to quote an instance already referred to, ammonium chloride heated to 360° C. is completely resolved into hydrogen chloride and ammonia; and the reverse effect—recombination between these bodies—occurs when the temperature is lowered.

Now the average velocity of an atom or molecule (for in this case they are identical) of helium existing as an ordinary gas at 0° C. is known to be 1.037×10^5 centimeters, or about 1⅛ kilometers, or in English measure approximately half a mile, per second. But the α-particle, or atom of helium, expelled from an exploding radium atom is about 2×10^9 centimeters, or nearly eighty thousand times as great. The squares of these velocities are to each other as the temperatures on the absolute scale; and as 0° C. corresponds to 273 Abs., we have the proportion: $(1.3 \times 10^5)^2 : (2 \times 10^9)^2 ::$ $273 : 6.5 \times 10^{10}$ degrees Centigrade; the last figure, expressed in words, is the enormous temperature of sixty-five thousand million degrees.

It is difficult to evaluate the temperature of a star; probably even the hottest does not surpass 100,000° C. If that be so, then the effective kinetic energy of an α-particle exceeds that of gaseous atoms in the hottest star by 6.5×10^5, or getting on to a million times. This energy can be brought to bear upon matter by mixing with it a radium salt, or, better, by dissolving in a solution of the compound to be treated some niton; for from niton a much greater number

of helium atoms are expelled in unit time than from even a much greater weight of radium.

The second available source of concentrated energy consists in the utilization of β-rays, either from radium or from the kathode terminal of a high-potential current. No definite experiments have been made with the former, except in so far as it has been shown by Cameron, and subsequently by Usher, working in the laboratory of University College, London, that the available energy of the β-, or kathode, rays from niton does not amount to one-fourteenth of that obtainable from the α-rays, judging by their action in effecting the decomposition of water into hydrogen and oxygen. The effective energy from the kathode terminal of a high-potential current obviously depends on the degree of potential, which is correlated with the velocity of the stream of the electrons, as well as on the quantity of the current, or, in other words, the number of electrons impelled from the kathode. In this latter case it is of course possible to give definite direction to the kathode stream, and even to concentrate it by the use of a spherical or parabolic kathode. Both of these methods have been employed with apparent success.

(1) It has been found on four separate occasions that a solution of copper sulphate, exposed to the action of niton, yields, after removal of the copper and evaporation, a residue in which the spectrum of lithium was recognized. Needless to say, a specimen of the same copper sulphate, under precisely similar conditions except that no niton was added to it, gave no trace of lithium; nor did distilled water containing an equal amount of niton give any mineral residue.

(2) It has also been found that there is a continual evolution of carbon dioxide from a solution of thorium nitrate, left to itself and tested at intervals of six months.

(3) Experiments on the action of niton on a solution of thorium nitrate have resulted in the production of carbon dioxide. The same solution was treated at intervals four times with fresh doses of niton, and the quantity of carbon dioxide formed was roughly proportional to the quantity of niton dissolved in it. The thorium nitrate was finally proved to have contained no compound of carbon.

(4) Other elements of the same group, of which carbon is the member of lowest atomic weight, viz., silicon (as hydrogen silicifluoride), titanium (as titanium sulphate), zirconium (as nitrate), cerium (as sulphate), and lead (as nitrate), were similarly treated with niton; all gave carbon dioxide, with the exception of cerium; and the quantity produced by the same dose of niton was in the same order as the atomic weight of the metal treated; silicon giving least and thorium most. Lead, however, gave a relatively small amount; and from solutions of silver and of mercury (as nitrates) no carbon dioxide appeared to be formed. But from bismuth (as nitrate) a trace was produced.

(5) When water contains niton in solution, it decomposes into oxygen and hydrogen. These gases, formed in relatively large amount, can be removed by explosion, and a constant small excess of hydrogen can be got rid of by addition of pure oxygen and explosion. The excess of oxygen can be withdrawn by exposure to charcoal cooled with liquid air; the residual gas consists of neon mixed with some helium. The presence of neon appears somewhat unaccountable, but it will be seen, further on, that we have a clue to its production; the helium is obviously one of the disintegration products of the niton.

This same change appears to take place in certain mineral springs containing niton; the gases evolved from the hot springs of Bath in England, consisting mostly of nitrogen,

contain about three-quarters as much argon as is normally present in atmospheric air; about sixty-five times as much helium, and about one hundred and eighty times as much neon. Hence, too, the neon evidently arises from the action of dissolved niton on water.

The action of kathode rays on the composition of matter has not as yet been examined, so far as I am aware, except in the two following instances. The first consisted in the examination of the blued glass of bulbs which had been used for the production of X-rays. Four of such bulbs, each of which had served for medical purposes for several months, were broken up, and the fragments of blue glass were placed in a combustion-tube. The air was exhausted and oxygen was admitted, so as to "wash away" all traces of air which might have conveyed with it traces of the gases for which it was prepared to test—helium and neon. The tube was finally exhausted and heated. The gases evolved, mainly oxygen which had been absorbed by the glass, were pumped off, and by the aid of charcoal cooled with liquid air all condensable gases were removed. There was a trace of residual gas, which on spectroscope examination proved to consist mainly of helium; but some feeble neon lines were recognized, showing the presence of a small trace of neon.

Professor Norman Collie undertook the next experiment. It consisted in bombarding with kathode rays a sample of calcium fluoride prepared by the addition of a solution of sodium fluoride to one of calcium chloride. The resulting precipitate was washed, dried and ignited. It was exposed for days to bombardment with kathode rays from a powerful Ruhmkorff coil. But under such circumstances the residual gas in the tube became absorbed, and in order to maintain the vacuum under suitable conditions for a kathode stream, pure oxygen was added from time to time. The first

portions of gas were rejected; but after nearly a week's bombardment about half a cubic centimeter was examined by the method already described. On examination of the gas remaining after absorption of the oxygen, etc., by cooled charcoal, the spectrum of pure neon was noted; helium was absent.

Although it would be inadvisable without further research to dogmatize on the results mentioned, it cannot but be regarded as important that in the absence of oxygen the product should consist of helium, while if oxygen be present neon is formed. The equation $O + He = Ne$, or, in figures, $16 + 4 = 20$, would appear to correspond with the change which has occurred. The formation of neon during the action of niton on water would thus also find an explanation, the oxygen being derived from the water and the helium from the niton.

We are merely at the beginning of such work. It will be difficult, owing to the small amounts of matter altered; but methods are being perfected not only to deal with minute quantities of material, but to weigh them with accuracy.[1]

Let us now inquire how electrons may be supposed to take part in such changes. We have as yet no clear mental picture of the structure of an atom; but from what has gone before, it appears evident that certain electrons, in union with the atoms of the substratum of metals, impart to them their metallic nature; it is these electrons which are more or less easily detached, and which correspond to valency. The non-metals appear to be distinguished by the possession of "latent electrons," which come into action during certain conditions of combination, and which also play the part of

[1] Note added May 23, 1915: Several papers have since been published on this subject by Collie and Patterson, by Masson, by Egerton, by Strutt, and by Merton in the "Proceedings of the Royal and Chemical Societies."

valency. The former, attached to metallic substrata, may be exemplified by the metal sodium, which we must now agree to regard as consisting of a substance in union with an electron; the latter, by chlorine, which in the chlorates, perchlorates, etc., develops valencies latent in its monovalent combinations, of which sodium chloride is an example.

Besides these easily detachable electrons, it is legitimate to speculate that whether or no there may be a material substratum to the atom, it contains other electrons, which by their number, their grouping, and their motion play a great part in determining its intrinsic and distinguishing properties.

The collision of an α-particle, or atom of helium, in rapid motion, or of an electron, with an atom, may take place either by a grazing impact or centrally. The chances in favor of a grazing impact are very much greater than those of a central collision. Probably out of every seventy collisions, one is central; the others merely affect what may be termed the "shell" of the atom.

Now it is known that the effect of α-particles or of β-corpuscles on gases is to ionize them. Ionization means the addition of an electron, or of more than one electron, to the atom of a gas; or it may equally mean the removal of one or more electrons from the atom of a gas. In the former case the ion is termed negative; in the latter, positive. Such ions, however, have no permanent existence; given time, they equalize their electric charges, or, in the language of the electronic theory, those having an electron more than necessary for the atomic existence of the gas pass on that electron to those having an electron less. Electric neutrality is thus reëstablished, and the gas loses its conducting power. The action of an α- or a β-particle is, in short, a reversible one, if only the shell of the atom is penetrated. "Valency-electrons"

are added or removed. The colliding α-particles pass through a gas at ordinary pressure for about seven centimeters before the rate of their motion is so diminished that impact with atoms no longer produces an ionizing effect. To use well known and conventional expressions, if the colliding atom or electron becomes slow-moving, then its impact will be so feeble as not to be able to overcome the "affinity" of the ionic electrons for the matter to which they are attached.

In the much rarer cases of a central or nearly central collision, the moving atom of helium or the moving electron penetrates the core of the atoms which it encounters; it must then play great havoc with their structure. The positions and motions of systems of electrons must then be profoundly disturbed; new and stable rearrangements will occur, and other forms of matter will result. In other words, a transmutation will be effected.

It is as certain as any fact can be that the loss of α-particles and of β-corpuscles by radium and its products leads to the transmutation of these bodies into others. They need not belong to the same chemical family; radium itself, a metal of the barium group, by the loss of an atom of helium yields niton, a gas of the inactive series. On the other hand, if reliance can be placed on the results obtained by treatment of members of the carbon column with niton, there is a tendency toward simplification to lower members of the same column; yet cerium, a metal generally regarded as one of the carbon group, fails to yield carbon as the result of disaggregation; and bismuth, an element quite free from any resemblance to those of the niton group, gives some carbon on such treatment.

Again, the formation of neon by the exposure of oxygen and some other body (glass, calcium fluoride?) to the kathode stream opens a way to the synthesis of elements. It

is true that the atomic weight of neon is 20.2, not 20.[1] But the addition of electrons may account for the increase in weight. As some 1800 electrons have a mass equal to that of an atom of hydrogen, the addition to an atom of helium plus one of oxygen of the fifth of 1800, or 360 electrons, would give the necessary increase in atomic weight, and such an addition does not seem impossible.

Nothing has been said regarding the periodic table in what has preceded, except to indicate that transformation does not always take place from the members of any one column to those of lower atomic weight in the same column; and it would at present be premature to speculate as to the ancestry or progeny of the elements. But as a working hypothesis it may be conjectured that while the existence of compounds between what we generally term elements consists in the juxtaposition of their atoms in such a fashion that the electrons of the "valency" order belonging to the combining atoms, which appear to be attached to the surface of the combining atoms, or which at least are easily removed, serve as "bonds" of union, the elements themselves are produced by the interaction of deeper-lying electrons. In fact, when one atom interpenetrates another, so that the deeper-lying electrons of one element influence those of another, what has been termed "transmutation" occurs. Or, conversely, an element of relatively high atomic weight may be induced to split into two or more "elementary" forms of matter; and it would appear probable that in order to produce such a fission the absorption and assimilation of a certain number of electrons is essential; or it may be the loss of some attached electrons. The latter alternative is certainly in operation when radioactive bodies disintegrate.

[1] Note added May 23, 1915: Ashton has brought forward some evidence for the supposition that there are two neons, the atomic weight of one being 20, and of the other, 20.2.

We are still in the dark as regards what happens when a radioactive element undergoes change with no expulsion of an α-particle. A specific instance is the change of radium D into radiums E_1 and E_2, and of the latter into radium F, or polonium. Here there is no helium atom lost; but β-rays, or electrons, are emitted at each stage. These have mass; hence the atomic weight of polonium should be somewhat lower than that of radium D. These two products of the disintegration of niton are at present being investigated at University College, London; and it may be said at once that their reactions are quite distinct, and that they can be separated from each other with the same ease as, say, arsenic can be separated from zinc. Further research will show whether their atomic weights are identical, or whether they differ by a small quantity, as, for example, the atomic weight of nickel differs from that of cobalt.

Attempts have been made, although with no definite results, to determine whether an "allotropic change"—*e.g.*, that of ozone into oxygen, or that of red into yellow phosphorus—is attended by the gain or expulsion of electrons. But it must be remembered that the usual test for electrons depends on the ionization of air by rapidly moving electrons, and that it is difficult to recognize electrons unless they are in rapid motion. It is true that an electric charge can be tested for and measured; but the existence of an electric charge is no proof that what may be termed "elemental electrons" have been gained or lost; the charge may be due to the gain or loss or the transference of "valency-electrons." It has thus not been shown that allotropy is due to gain or loss of elemental electrons; in all probability it is not, but to the familiar rearrangement of the atoms of a compound, for which we generally use the term "isomerism."

Enough has now been said to show the nature of the prob-

lems which await solution. Progress must of necessity be slow; but methods of micro-analysis have now been much improved, and the microb-lance affords a means whereby quantities of matter of the small order which must be handled can readily be weighed. The field is ripe unto the harvest, but as yet the laborers are few.

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